This Month's Cover: Systematic design, discussed in the article beginning on Page 126, was employed by Askania Regulator Co. in developing this electromechanical unit for generating functions of natural logarithms.

MACHINE DESIGN

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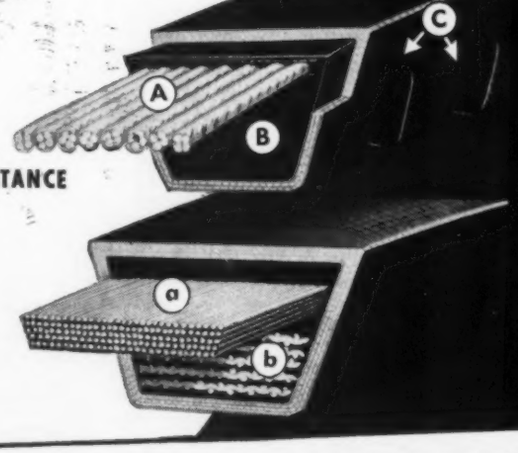

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TOPICS

STROBOSCOPE for "stopping" motions recurring as often as 300,000 times per second has been developed by the Naval Ordnance Laboratory. Instead of synchronized high-intensity flashing light, an electron tube with variable pulse rate illuminates the subject. The observer watches the action through a fluorescent viewing screen. Also, with the tube serving as a camera shutter, photos can be made with 16-mm lens.

SURFACE CARBON CONTENT of steel during carburizing is automatically controlled by a new Leeds and Northrup instrument. Carbon potential of a furnace atmosphere is "sensed" by an electrical element projecting into the furnace work chamber. Connected to this element is a unit which adjusts the flow of carburizing fluid to hold the potential at any selected value between 0.15 and 1.15 per cent carbon.

STRAIN GAGES are being used as fuel gages for rockets in NACA laboratory tests. Attached to the structure supporting the liquid-fuel tanks, the gages indicate tank weight and, thus, fuel content.

ELECTRIC GOVERNOR being developed by the Navy for small generating plants reacts to any change in load current instead of generator speed. The generator will restore engine speed and frequency to within 0.5 per cent within one-half second after change from 0 to 100 load and will maintain steady load speed within 0.25 per cent.

STAINLESS STEEL discolored in welding can be cleaned by a method developed by Armco Steel Corp. With an acid solution (phosphoric, nitric or hydrochloric) a direct-current power source and a copper "cleaning" rod, discoloration can be removed at a rate of two feet per minute. Light scale also can be removed but not heavy scale or weld slag.

HOT-LACQUER PROCESS, wherein lacquer is heated to make it more fluid and sprayed while hot, is proving to be an economical finishing method. According to Hercules Powder Co., solid content of the lacquer can be increased from 21 to 30 per cent. With higher solid content, less solvent is wasted, fewer coats are needed, and properties such as "flow-out," sag resistance, and toughness are improved.

BOROCARBON RESISTORS offering resistance ranges heretofore impossible with stable film type resistors have been developed by Bell Telephone Laboratories. In the new resistor, borocarbon films are deposited on a suitable ceramic core by the thermal decomposition of gaseous compounds of these elements. The relatively small and predictable temperature coefficients of the resistors depend on film thickness and boron content.

MARKINGS ON STAINLESS STEEL can be permanently applied by a method developed by Stainless Ornamentals Inc. Designs or markings are black and are claimed to have anticorrosive qualities equal to stainless steel. The process is applicable to dials, signs, name plates, etc. Photographs (up to 132 screen halftones) can be reproduced on stainless steel also.

OCTOPROP, an 8-blade dual-rotation airscrew, is being tested by the Air Force. Designed by Curtiss-Wright, the unit is 19 feet in diameter and has been planned for operation with turbo-engines up to 15,000 horsepower.

SILICONE RUBBER of a new type has been developed by General Electric. Parts can be fabricated from the new compound without prolonged oven cure and may easily be molded and extruded after a five-minute warm-up. Parts with undercuts can be easily removed from molds because of high hot-tear strength. The rubber remains serviceable over a temperature range of 550 to −85 F.

HUMAN ENGINEERING DATA has been compiled at Tufts College under Navy contract in the form of a systematic treatise on the science of designing mechanical equipment consistent with human capabilities. Entitled *Handbook of Human Engineering Data for Design Engineers,* the book deals with vision, hearing, motor responses, space orientation, anthropometrics, and physiological factors.

MACHINE DESIGN
A PENTON PUBLICATION

. . . Not a Machine But a Life

SOMETIMES it appears that the ingenuity of machine designers in devising clever mechanisms is matched by the ability of machine users in finding ways to injure themselves and damage the mechanisms. Wherever there are moving parts, of course, there is potential hazard to life, limb and property, although most of the present machinery-conscious generation has acquired a healthy respect for the dangers. However, there are still the clumsy ones, the foolhardy ones, and the deliberate tamperers.

Accidents are at best unpleasant occurrences. We would like to look the other way and shrug them off as consequences of carelessness. But as Sigurd Rudorf points out elsewhere in this issue, every so-called human failure in the operation of machinery can be charged, at least in part, to the designer.

Unfortunately many machinery accidents are followed up merely by a tightening of safety regulations and possibly also by the addition of some sort of makeshift safeguard to the machine involved. The one step that would get to the heart of the matter and really promote long-range safety too often is omitted—that of notifying the machinery manufacturer concerning all details of the accident, so that the necessary safeguards may be incorporated in future designs and, possibly, modifications made available to other users of existing machines.

Initiative for a positive program to insure that designs will meet all reasonable—and perhaps some unreasonable—safety requirements must come from the engineering department of the machinery builder. What steps might be taken to start a program of this kind? Rules such as those suggested in Mr. Rudorf's article can be formulated and established as part of standard design procedure. Users can be encouraged to submit data on any accidents, perhaps by such devices as periodic questionnaires which would make it easy to report the details. Quite apart from the economic soundness of designing for safety is the human appeal, which should be effective in enlisting the enthusiastic co-operation of all concerned. As James E. Trainer recently told the Gray Iron Founders' Society, the objectives might be stated in terms of saving not a camera but an eye, not a compressor but a lung, not a pump but a heart, not lubricant but blood, not a machine but a life.

Colin Carmichael

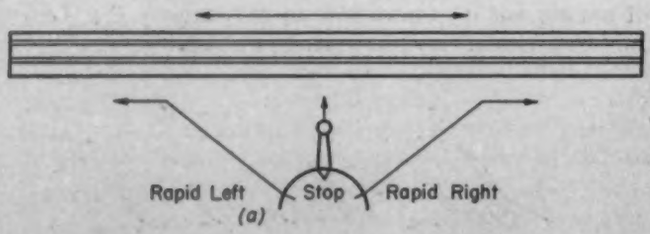
EDITOR

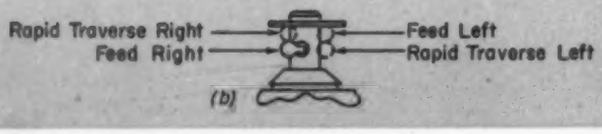
Fig. 1—Above—Nonfunctional control design, explained in Fig. 5, was a major factor in this $50,000 smash up

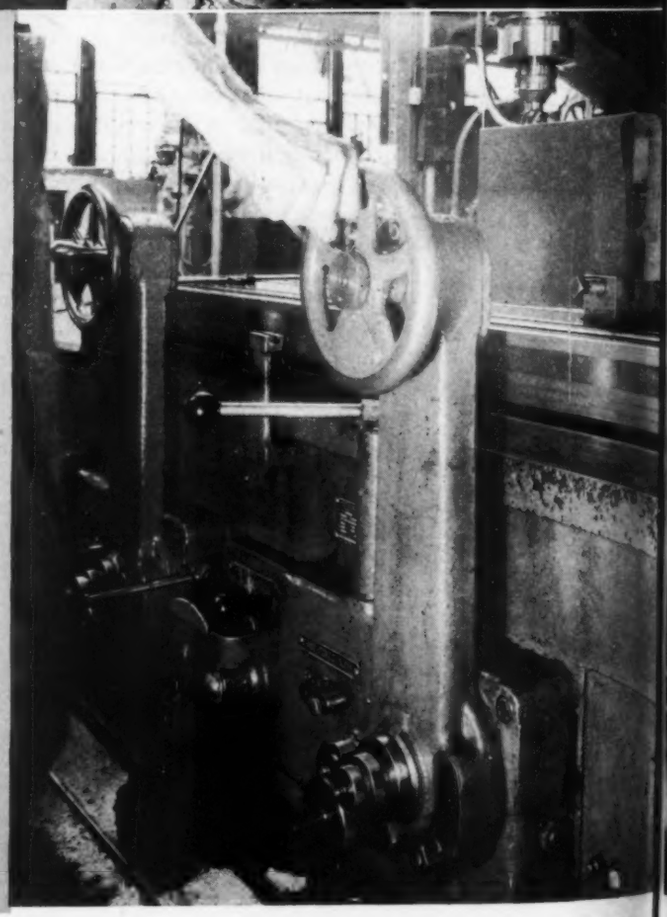
Fig. 2—Below—In functional control-lever design (a), response is in same direction as movement of lever and speed increases with lever displacement. In nonfunctional design (b), if "up" and "right" produces "feed left", operator would logically assume that "up" and left" would produce "feed right." Getting "rapid" instead has led to machine damage and personal injuries

Fig. 3—Right—Motion of the table is directly proportional to handwheel rotation in this application of directional rotary servo control to a milling machine

Fig. 4—Extreme right—This detent-type directional control is simple but effective







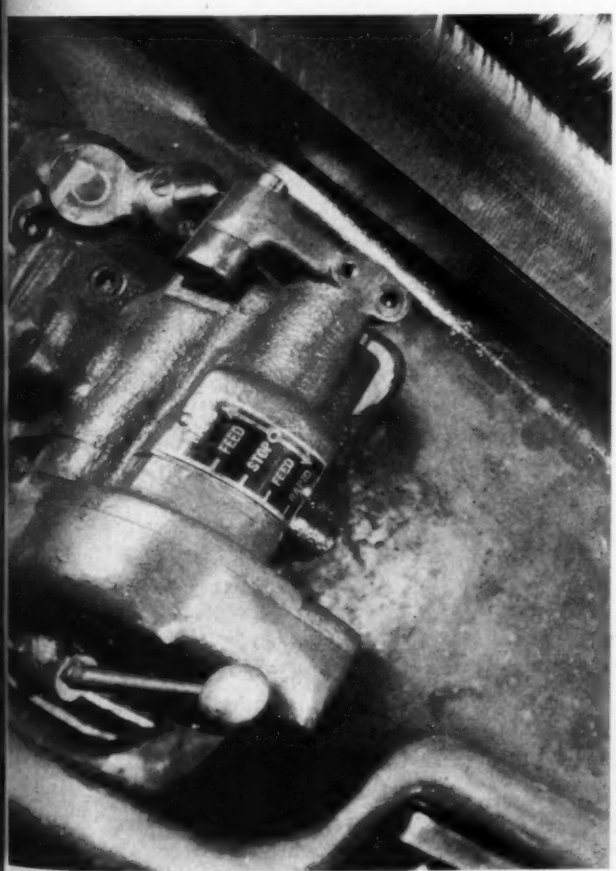
Design for Safety

How machine designers can improve controls and reduce costs while promoting safe operation

By Sigurd K. Rudorf
Superintendent, Maintenance
General Machinery Div.
Allis-Chalmers Manufacturing Co.
Milwaukee, Wis.

COMPLETING an uneventful flight some time ago, a huge four-engined airliner gracefully touched its wheels to the runway at Shannon Airport, Ireland. During the landing run, the pilot called for "up flaps", a routine function of the co-pilot. Seconds later the $1,300,000 airplane was a pile of junk.

The investigation that followed revealed that a simple and human mistake was a basic cause of the accident. The copilot, familiar with the control locations of another type of plane he had flown for many months, inadvertently operated the landing gear lever, retracting the wheels and dropping the moving plane to the pavement.



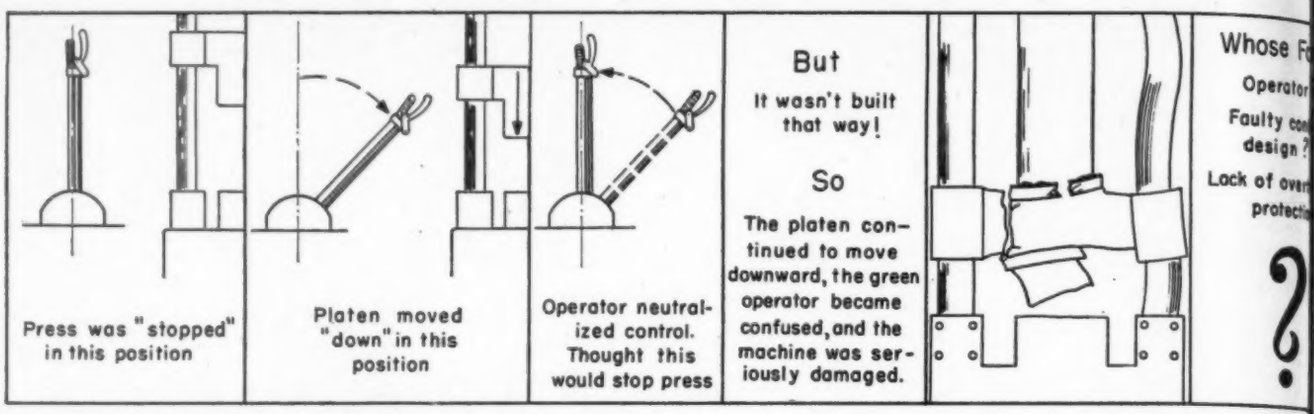
Investigators attributed this spectacular disaster to human failure alone (as we are apt to do when a machine operator runs a carriage beyond its limits, or plows a fixture off a milling machine table because a control-lever action is alien to him). But this crack-up and other hard lessons have led the aircraft people to do more constructive work on control simplification and standardization than any other group.

They have devised control knobs of contrasting shapes with functional movements in logical locations, have grouped instruments to facilitate reading, and have done much other constructive work. This was brought about by the aircraft industry's recognition that not every "human" failure can be attributed solely to the operator but, in part, must be charged to the machine designer.

In this same sense, machine builders cannot escape a measure of criticism of their products. Although most of them state that they have given much thought to functional controls, the products of their labors often fail to reflect this endeavor, *Fig.* 1.

The purpose of this article is to discuss a number of safety thoughts from a machine user's point of view, without dwelling long on spinning handwheels and other well-known ghosts. Although the connection of these thoughts to safety considerations is not always direct or even clear, this discussion is predicated on the premise that when the designer simplifies controls, removes distraction and doubts, and eliminates need for close concentration, he directly or indirectly promotes accident prevention and reduces costs. In this spirit, the following recommendations are made.

Several obvious fundamentals apply to the design of control levers. All control levers should be so ar-



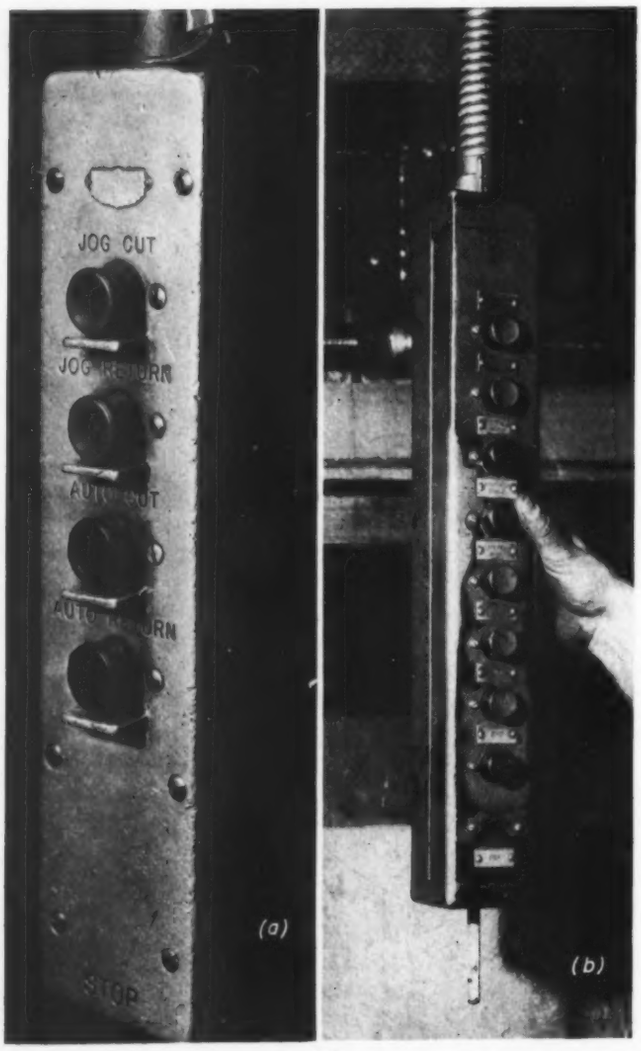


Fig. 5—Above—This is the story of the mishap shown in Fig. 1

Fig. 6—Left—Controls should be positively identified. Panel arrangement (a) shows one of many ways to relate each button to its name plate. As in (b) confusion can result from failure to "tie up" a button and its identification

Fig. 7—Left below—Many common control peculiarities are traditional but still confusing

ranged that machine components move in the direction in which the lever is moved, *Fig.* 2. So far as possible, a *small* movement of the lever should initiate "feed", or slow movement. A *further* movement should produce "rapid traverse", or accelerate motion, *Figs.* 3 and 4. Accidental overmovement into "rapid" position must be prevented by a thumb-operated latch or similar lock gate.

Several motions of a machine, where possible, should be combined into a single "joy stick" type of control. For instance, the table of a knee-type milling machine could be operated by a single perpendicular control stick which could be moved progressively to two positions in each of four directions. "First position right" would cause the table to feed to the right. "Second position toward column" would rapid-traverse the table toward column, etc. The reasoning here is that a single lever would become associated with the table. The directional feature is as elementary as leading the proverbial horse to water.

If *moving* a lever to a given position produces a given motion, *returning* the lever to its original position should *arrest* the motion. *Figs.* 1 and 5 graphically show the results of one violation of this rule.

Controls should be so marked that the name plate clearly identifies the control function, *Fig.* 6*a*. Obviously, in an emergency there is no time to check if the button *above* or *below* the inscription is meant, *Fig.* 6*b*. Although it is difficult to depart from time-honored control peculiarities, uniformity should be a goal, *Fig.* 7.

Machine components should be so arranged that they are protected against overtravel. Preferably this protection should be provided through automatic declutching of drive gearing, de-energizing of driving motors, through overload friction or ratchet clutches, or as a last resort, through shear pins. Simply indicating by a line or marker that feed must be discontinued at a certain point is not sufficient. Un-

fortunately, a lathe compound cannot be protected against being carelessly run against a work piece. The odds are against it, though, since the operator is more likely to be watching the tool (and therefore the compound) in relation to the work. However, protection should be planned against inadvertently running a slide into its "dead end" with consequent damage to the machine.

Speaking of overloads—few machines are potentially as dangerous as overhead cranes. They are frequently subjected to abuse through overloading. Yet, they are among the least protected against either accidental or willful damage. Most cranes will lift loads that are great enough to tear cables, deform bridges, or damage brakes. It is recommended that cranes be so arranged that it is impossible for the operator to pick up unsafe loads without being warned or using emergency procedures.

No machine builder is expected to be conversant with the different and changing safety codes of the 48 states. The National Machine Tool Builders' Code is a welcome step in the direction of standardization. It is expected, however, that all agents selling machine tools should be sufficiently familiar with the codes of the states in which they do business to point out to users the ways in which their products meet with local law or fail to comply, and to convey to their principals the modifications needed for acceptance.

It is not expected that the builder of a $150.00 drill press should make individual changes to satisfy local requirements. It is expected, however, that builders of major or special machines should comply with state laws. For several years at Allis-Chalmers, it has been gratifying to note that after insistence that the equipment covered by purchase orders meet local state code requirements, no refusals have been encountered and no requests received for additional remuneration. Builders apparently feel that such requests are reasonable.

As an aid to safety as well as to getting the most

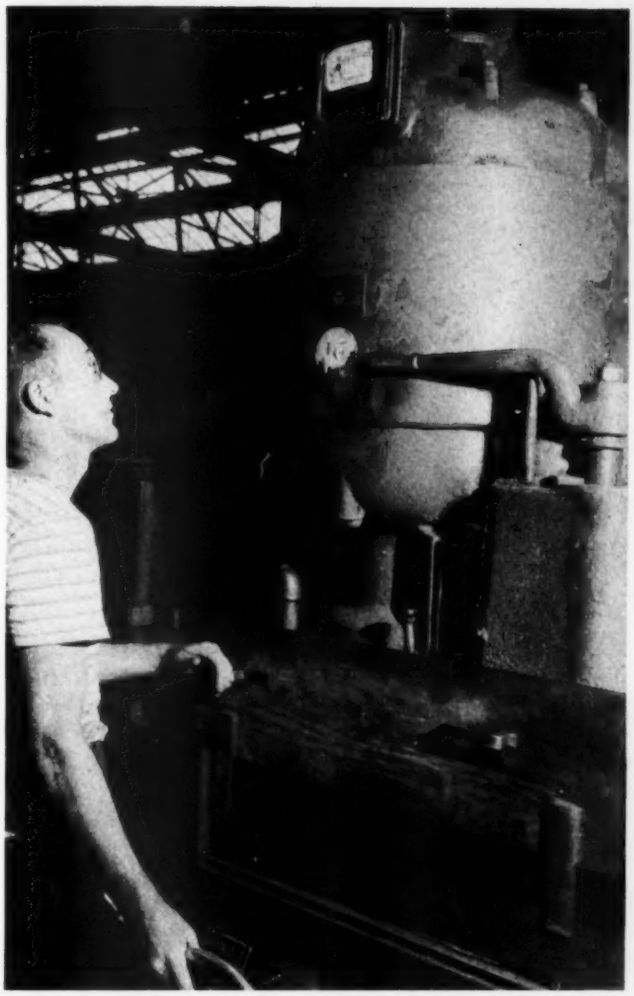
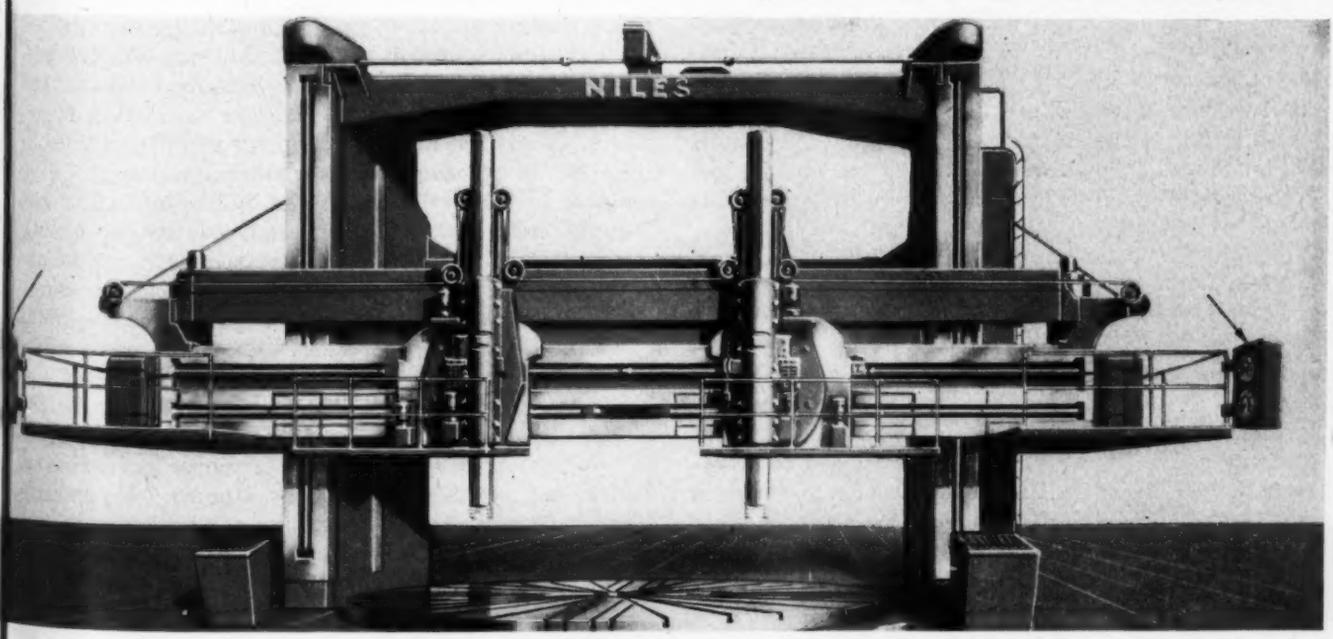


Fig. 8—Above—On grinding machines electrical load indicators are frequently the only practical means of limiting the feed rates to those that work and machine can stand

Fig. 9—Below—Large machines afford an operator no "feel" of load and tool pressure; he must rely on instrumentation. On this 30-ft boring mill, with dual variable-speed constant-torque drive, meters indicated by arrows show percentage of available horsepower being consumed by the cut as well as feed rates and table speed



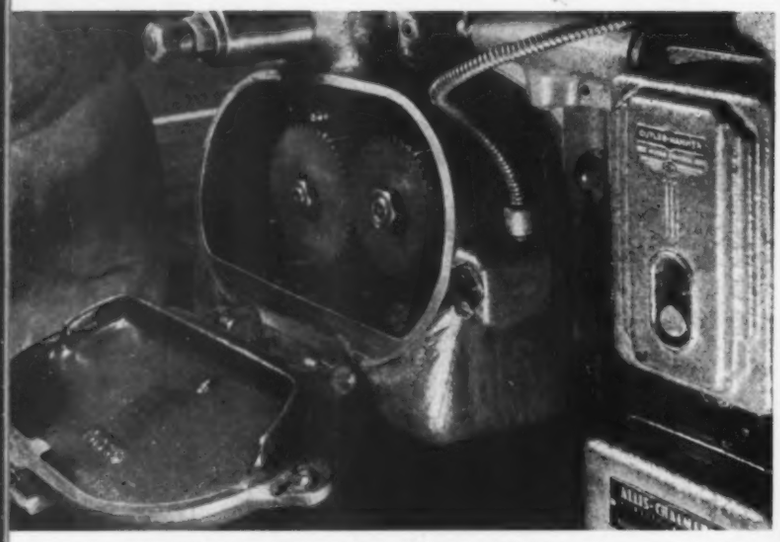


Fig. 10—Above—As shown here, gear box covers and other access doors should be electrically interlocked to prevent accidental starting

Fig. 11—Right—To prevent confusion, means of measurement should be direct and simple. Good design is exemplified by this drum counter with conventional vernier collar for a modern jig-boring machine

out of a machine, indicators should be provided to show the horsepower consumed with a given cut, *Figs.* 8 and 9. In the case of variable-speed d-c equipment, it should show the percentage of available power being used, since horsepower may vary with speed. These readings would help the operator produce more work as well as protect the machine against mechanical abuse.

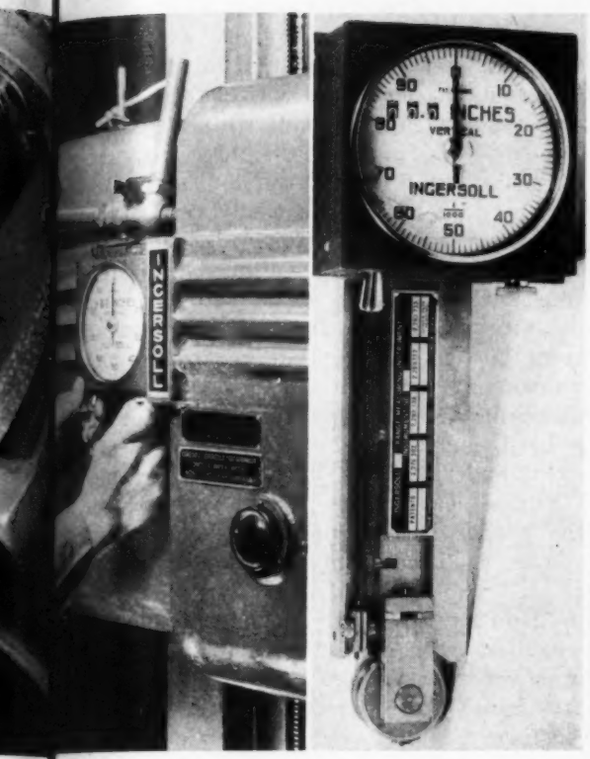
Pick-off gear box covers and other frequently used access doors should be electrically interlocked to prevent accidental operation and injury, *Fig.* 10. Although some builders have done this for many years, not all have followed this practice.

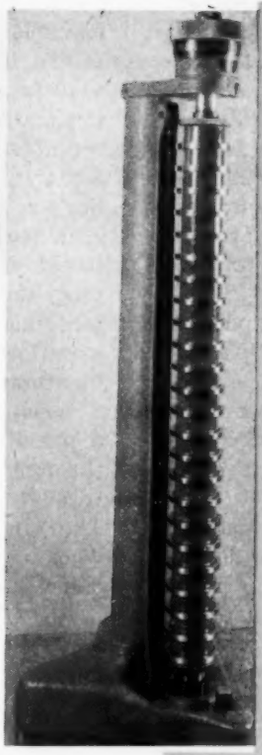
Air-chuck equipped machines are usually provided with pressure switches to shut down the spindles when work-holding forces drop below predetermined values. This practice should not only be universally followed, but care must be taken that there is sufficient reservoir capacity in the piping system (or check valves provided) to assure that, even in the event of pipe joint rupture or hose failure, enough air is trapped to hold the work until the spindle has been brought to a stop. Installations have been observed where the pressure switch would not have prevented an accident if any of a variety of possible failures had occurred.

The number of different types of graduated collars on handwheel hubs is a frequent source of error. Certain lathes have cross-feed graduations representing the true advance of the cross slide. In other words, feeding the wheel 0.010-inch would reduce the workpiece diameter by 0.020-inch. In a questionable effort toward simplification, other machine builders make their graduations represent one-half of true motion, so that rotating the wheel 0.010-inch produces 0.005-inch forward motion, with a resultant 0.010-inch reduction of workpiece diameter. To add to the general confusion, series of two or three geared dials are sometimes used, reading in inches and thousandths. Both opposite and like rotation have been used. Although direct-reading drum counters or dial-drum combination units, such as illustrated in *Fig.* 11, are favored, it is believed that an effort toward standardization by the industry as a whole might produce less expensive solutions.

A fundamental of the manufacturing business is precise measurement. The scale, even when vernier equipped, is inaccurate and produces eye fatigue accompanied by errors. Length measures and indicators, such as used on jig borers, are accurate but slow. Electrical positioning-to-length measures are better, but expensive and still too slow. Geared drum counters cannot stand high speeds resulting from fast traverses. Dial-drum type measuring instruments are a close approach to a solution, *Fig.* 12, but present accuracy problems where traverse distances are more than a few feet. It must be concluded, therefore, that the problem is not solved. The ideal objective is to show dimensions accurately to four places as sets of figures on well lighted dials. Thought might be given to an interim solution: confining measurements to the short distances that can be accommodated by present day dial indicators, say 1 inch, and obtaining the major portion of the total distance from racks or bars with 1-inch pitch reference surfaces. In other words, this could be an application of the principle exemplified by the height gage shown in *Fig.* 13.

Coolant reservoirs and chip removal provisions at long last are beginning to be studied. Necessarily and certainly traditionally, ways are often placed where they take the brunt of chips, coolant and falling parts. Certainly it is not inconceivable that lathe ways might be arranged to the *rear* of the





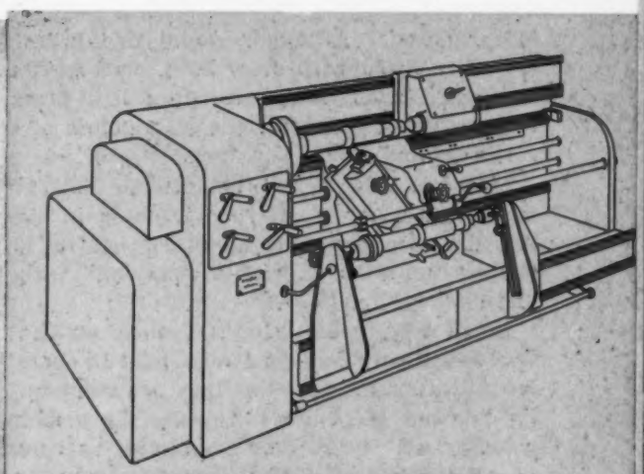
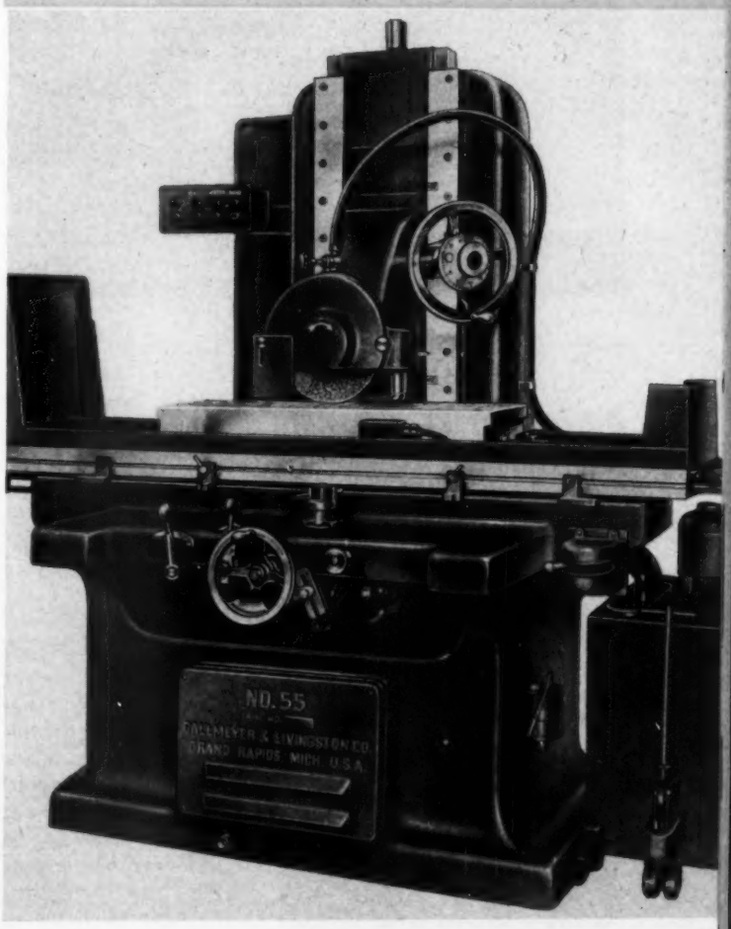


Fig. 12—Extreme left—Easily read dial-drum indicators are also effective for transverse distances up to several feet

Fig. 13—Left—A possible solution to the problem of accuracy over great distances is suggested by this height gage which combines a series of 1-inch reference blocks

Fig. 14—Above—Damage to lathe ways from chips, coolant, falling parts, etc. might conceivably be prevented by a revolution in lathe design. Special covers and possible failure to detect advanced scoring would be eliminated

Fig. 15—Below—Separate coolant sumps should be employed wherever possible



workpiece, instead of under it, *Fig.* 14. This might make it unnecessary to cover ways for protection, a practice that may result in advanced damage before routine inspection reveals scoring. In any event, chip pans should be easy to clean, and elementary as it may sound, should be *generously sloped* for drainage.

Separate coolant sumps are favored where they can be applied. *Fig.* 15 shows an easily maintained design. *Fig.* 16, rather common to many machines, is an example of inaccessible construction. Although separate sumps may be frowned upon by the exponents of "streamlined" design, it should be remembered that a machine lives an earthbound, stationary life in intimate contact with people. Cleanliness and serviceability should not be secondary to appearance.

Much thought must be given to the design of machines to enable the operators to load and unload them without undue exertion or hazard. It appears that ready solutions have been found for the complicated handling problems. Yet, some of the simple ones have been neglected. An example is the common hand-operated arbor press, *Fig.* 17. Although much of its work requires pressing shafts out of disks, it is usually so arranged that the shaft drops out, endangering the operator's feet. Loading it is also awkward since the over-hanging C-frame complicates the use of lifting equipment on heavy parts.

Within the author's experience in a single large plant, five serious finger accidents were caused when heavy tools dropped out of drill press spindles. Obviously, a retaining device is required. Yet, the manufacturers naively say that *if* the tool shanks and *if* the spindle tapers are in good condition, and *if* the tool is properly inserted, no lock is needed. When a list of "if's" is the best that can be done for a man with a mashed finger, faith in our ingenuity

is misplaced. Although radial drill-press spindles are often fitted with draw keys, such keys are cumbersome. It is time that better drill-press spindle ends be developed, from the standpoints of both tool retention and torque capacity.

Machines should be arranged so that no spindle creep can occur when the clutch is in the neutral position. On many machines, the neutral is precariously established only after "playing" with forward and reverse directions.

Small high-speed grinders, such as the popular double-end carbide type are so quiet in operation that operators may not realize they are running. A pilot light is not the answer, because the machines coast a long time. Since they are almost universally used on alternating current, perhaps a stroboscopic effect could be created to clearly show motion.

All machines should have a standardized pad for machine serial number and other related information. This pad should be in an accessible spot for rapid perusal. Perhaps there would then be little need for step ladders, flashlights, mirrors, and grease scrapers in finding and reading serial or machine tool numbers.

The nature of work at Allis-Chalmers is such that both alternating and direct current are used in a wide range of voltages. As a consequence, it has been necessary to standardize on certain types of receptacles and plugs for specified current characteristics. Incoming machine tools, however, are naturally often out of step with these private "standards." As an example, a certain three-prong receptacle in the plant means 110-volt single-phase current, with one prong used for the grounding lead. An optical form grinding machine employing a detachable wheel head was recently delivered with an identical three-prong receptacle, internally wired for 440-volt 3-phase power. Serious burns or loss of life can easily result from such serious disagreements of standards. It is believed that the industries involved must work out plug and receptacle standards which will not interfere unduly with the design freedom of individual manufacturers but yet assure that hazardous combinations cannot be assembled.

When a machine accessory, such as a d-c chuck or a grinding head, is freely removable and connected through a plug and receptacle, it should be grounded through a ground lead in the plug-in arrangement. The obvious purpose is to eliminate shock hazard when the device is lifted from its "grounding" machine pad.

At Allis-Chalmers, 110-volt control circuits are generally required, with control current supplied by built-in transformers. Voltage at the push button stations is limited for obvious reasons—and the built-in transformer is preferred so that a single disconnect switch will definitely de-energize the entire machine. Another preference is for dust-tight fan or blower-cooled motors on machines exposed to or creating cast-iron dust, with control enclosures similarily arranged.

Although the potential hazard is clear, manual-type starters are found on machines that are inherently dangerous in the event of accidental starting. Obviously, only magnetic starters which drop out and stay out after power failure should be used on such machines.

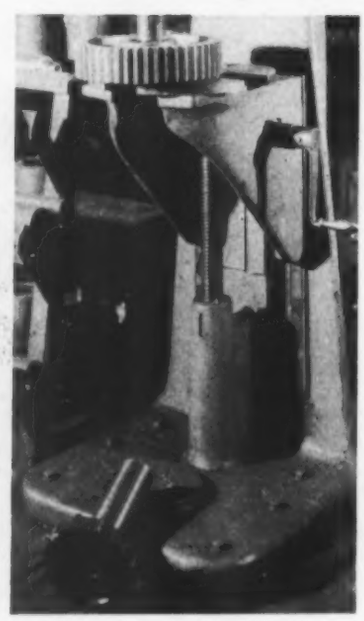


Fig. 16 — Above — Built-in sumps are often inaccessible—and neglected

Fig. 17—Left—Hand-operated arbor press, though time-honored, is inherently unsafe. Operator's feet are endangered by the dropping shaft and loading is awkward because of the over-hanging construction

Centralized Power Control Essential

From the point of view of safe maintenance, there remains for each plant management the task of establishing a single location at which all forms of power can be disconnected from the machine and locked. Usually, a simple disconnect switch and personal padlock for each maintenance man serves the purpose. In more complex machines, more elaborate precautions may be required. In any event, shutdown procedure must be clear—and enforced.

In conclusion, it is admitted that it is easy to criticize the endeavors of others. When unhampered by practical consideration, uninhibited imagination can conjure up visions of tomorrow's machines—so productive, so convenient, so trouble-free and safe, that there would be nothing left to talk about. Such machines are the ultimate goal. Toward it, builders and users have made substantial strides. In the interim, however, there is much left to talk about.

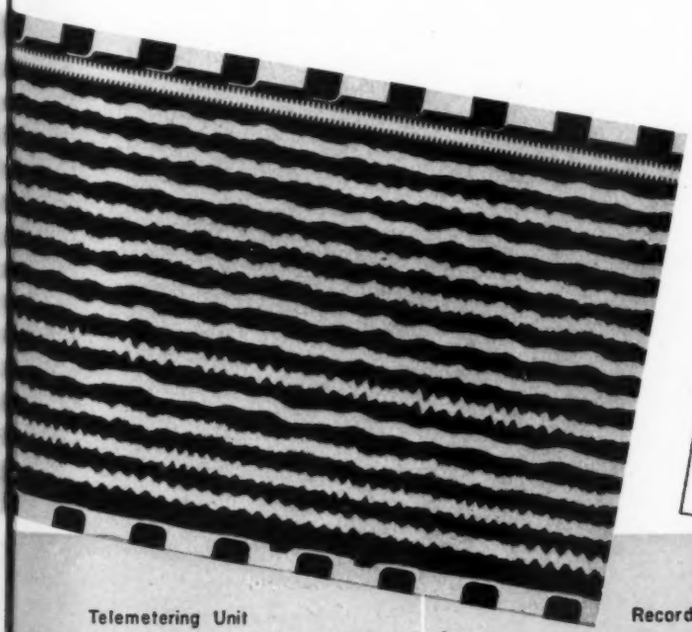
The author acknowledges the helpful co-operation of the following companies in furnishing illustrations for this article:

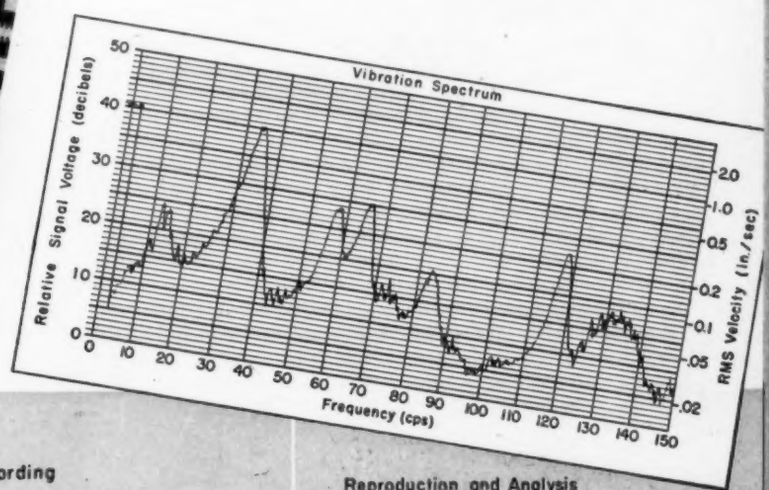
Cadillac Gage Co. (*Fig.* 13) ..... Detroit
Gallmeyer & Livingston Co. (*Fig.* 15) Grand Rapids, Mich.
Ingersoll Milling Machine Co. (*Fig.* 12) .... Rockford, Ill.
Kearney & Trecker Corp. (*Fig.* 11) ..... Milwaukee
Niles Tool Works (*Fig.* 9) ..... Hamilton, Ohio
Sundstrand Co. (*Fig.* 4) ..... Rockford, Ill.

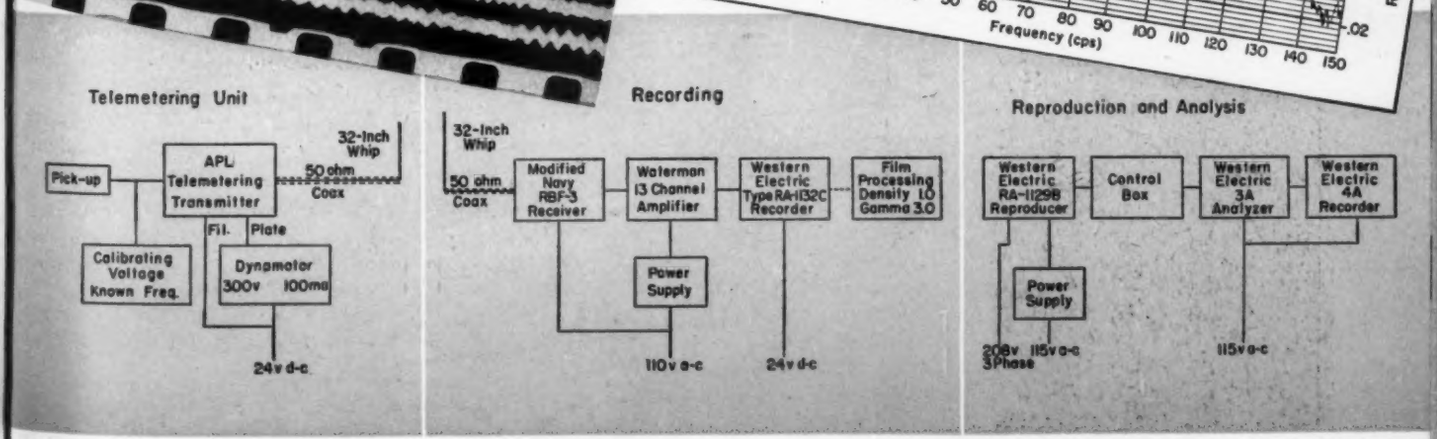
SCANNING the Field For Ideas

Telemetered vibration data, gathered from inaccessible locations on fighter and conventional aircraft for example, may be recorded and analyzed into useful form with a minimum of effort by using the system illustrated below. Developed by C. B. Cunningham, Applied Mathematics Branch, Mechanics Division, Naval Research Laboratory, the system converts vibration into an electrical signal. A velocity type pickup is employed because it has a low-impedance output sufficiently large to modulate a telemetering transmitter without any associated amplifiers or oscillators. Output from the pick-up is fed to a telemetering transmitter operating at 85 megacycles. With a 32-inch whip antenna and 24-volt supply from the plane's battery, reliable operating ranges of 50 miles with a plane altitude of 3000 feet are normal.

Recording of vibration data is also shown by a block diagram wherein the frequency-modulated telemetered signal is received by a modified Navy type RBF-3 receiver. The output from this discriminator is fed to at least four channels of a multichannel amplifier whose output is then fed to an equal number of recording channels of a Western Electric Mirragraph recorder. Each amplifier is set at a different gain level so that the vibration signal will be within the dynamic range of the recording equipment, which is essentially 13 sound channels recording on 35 millimeter film. The signal voltage is







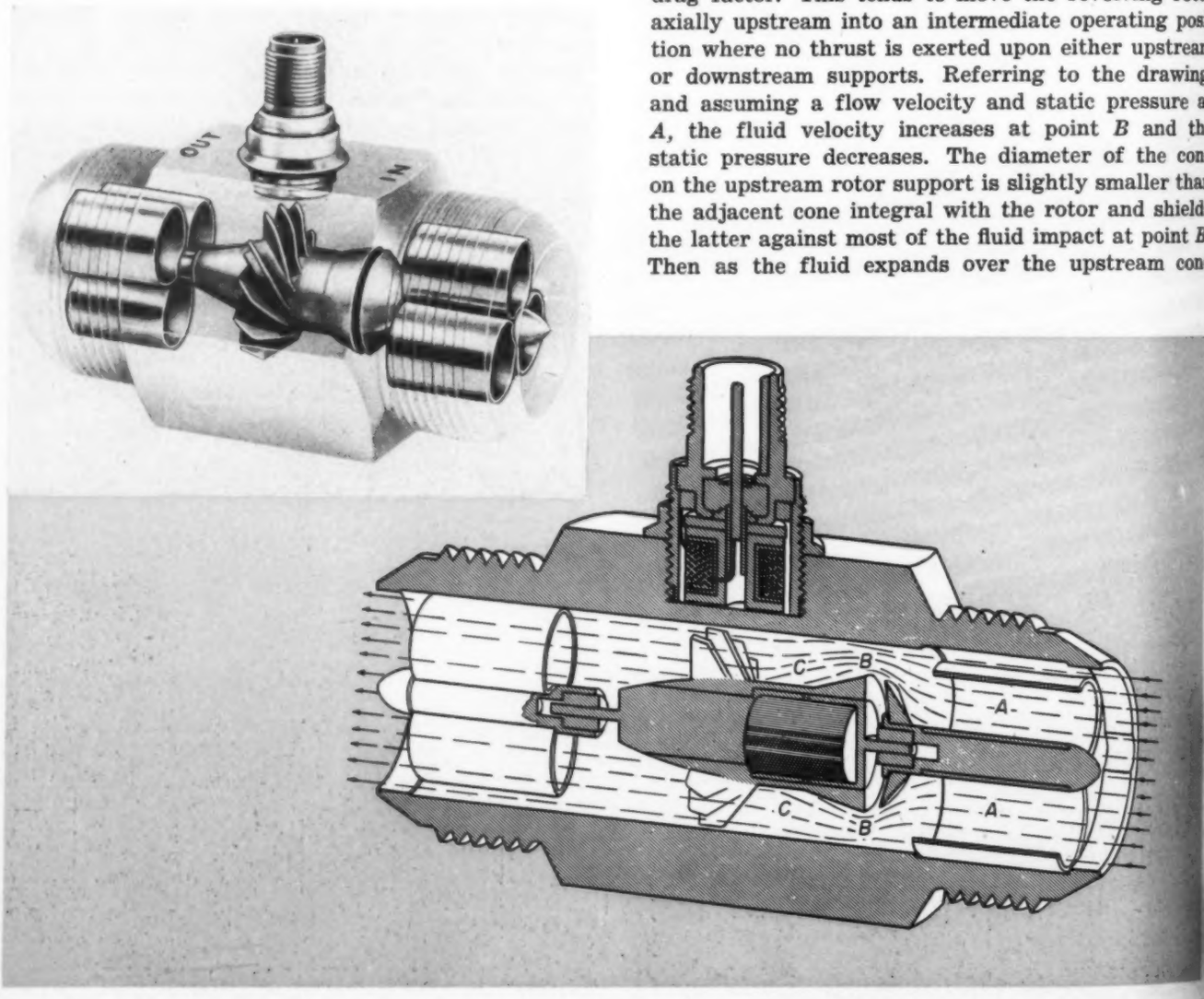
applied to a flat galvanometer ribbon which is displaced laterally. A shadow of this ribbon is projected through a narrow lateral slit on the moving film.

The block diagram for reproduction and analysis shows equipment for graphing a vibration spectrum from the film made in the recording section. A selected section of film is made into a loop and put into the reproducer which scans one-half of each trace photoelectrically through a narrow slit so that in effect the film is a variable area recording. Output from the reproducer is an electrical signal whose amplitude and frequency characteristics are similar to the original signal fed to the telemetering transmitter. The recording of a known input to the telemetering transmitter permits calibration of the system so that exact signal levels may be determined. Reproduced signals are fed through a frequency analyzer to a recorder which plots the output level in decibels against frequency.

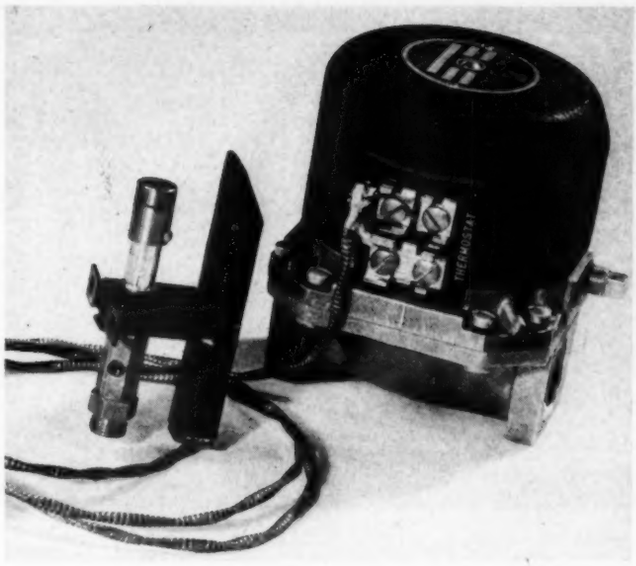
Frequency response of the entire system is flat within one decibel from 3 to 5000 cycles per second. Frequencies may be determined to an accuracy of 3 per cent and amplitudes within 10 per cent. For vibration measurements frequency response is, for all practical purposes, limited by the vibration pick-up to a range of 5 to 1000 cps. Shown is a typical film recording of thirteen channels and a vibration spectrum obtained from the analyzer for a radar antenna reflector mounted under a single-engined aircraft, showing the maximum vibration amplitude occurring at this location during normal flight.

Electronic flowmeter, below, incorporates a novel, high-efficiency sensing rotor which spins freely within a venturi. Designed by the Potter Aeronautical Co., the new design eliminates undesirable features such as bearing maintenance, friction drag and high-pressure drop. The flow sensing rotor is dynamically balanced and contains a magnet to excite an external pick-up coil connected to an electronic instrument for measuring the flow. Speed of the rotor is determined by the velocity of the fluid passing through the housing and by the pitch of the rotor blades.

Fluid flow around the rotor establishes upstream thrust components which exceed the downstream drag factor. This tends to move the revolving rotor axially upstream into an intermediate operating position where no thrust is exerted upon either upstream or downstream supports. Referring to the drawing, and assuming a flow velocity and static pressure at *A*, the fluid velocity increases at point *B* and the static pressure decreases. The diameter of the cone on the upstream rotor support is slightly smaller than the adjacent cone integral with the rotor and shields the latter against most of the fluid impact at point *B*. Then as the fluid expands over the upstream cone



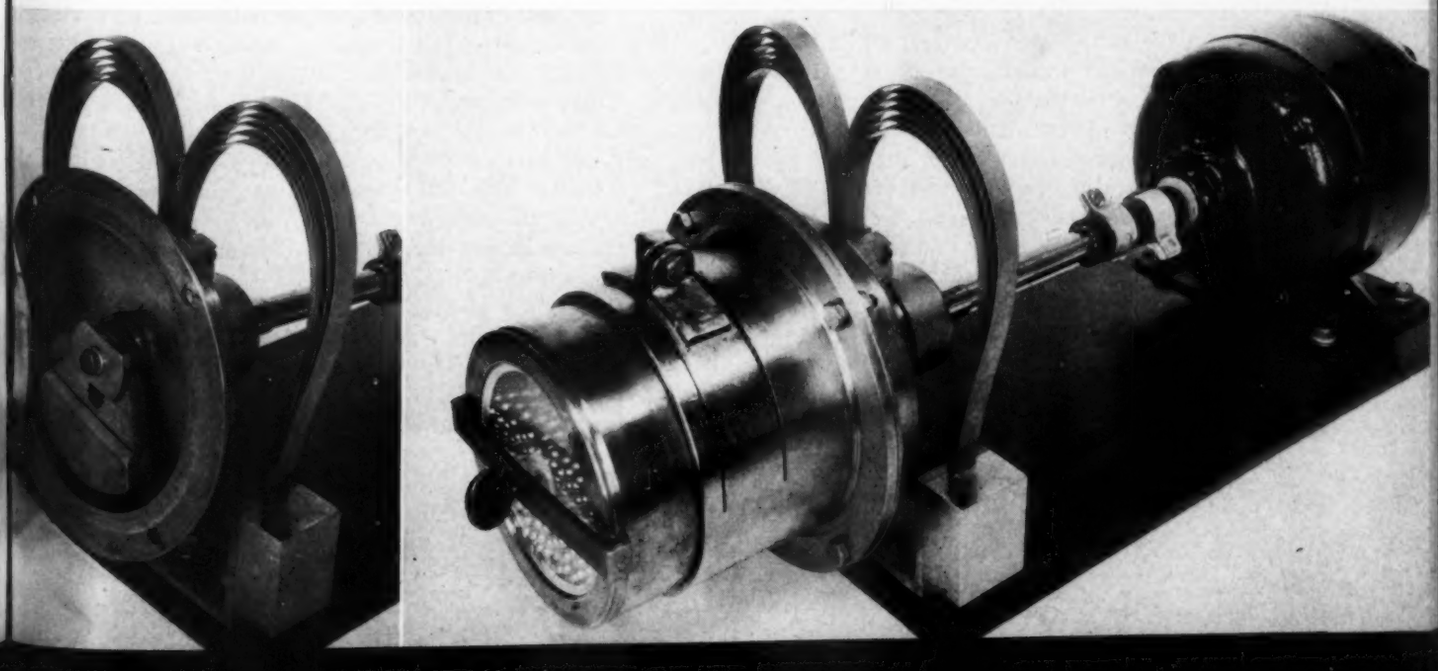
of the rotor at point *C*, the velocity decreases and the pressure increases to almost the same value as at *A*. Therefore there will be a net thrust in the upstream direction. Because the rotor reaches a balanced position, no thrust bearings are needed and a small-diameter rotor shaft and short guide bearings are employed. With no loading of the blades on the rotor, the pressure drop is directly related to venturi efficiency which can be made high.

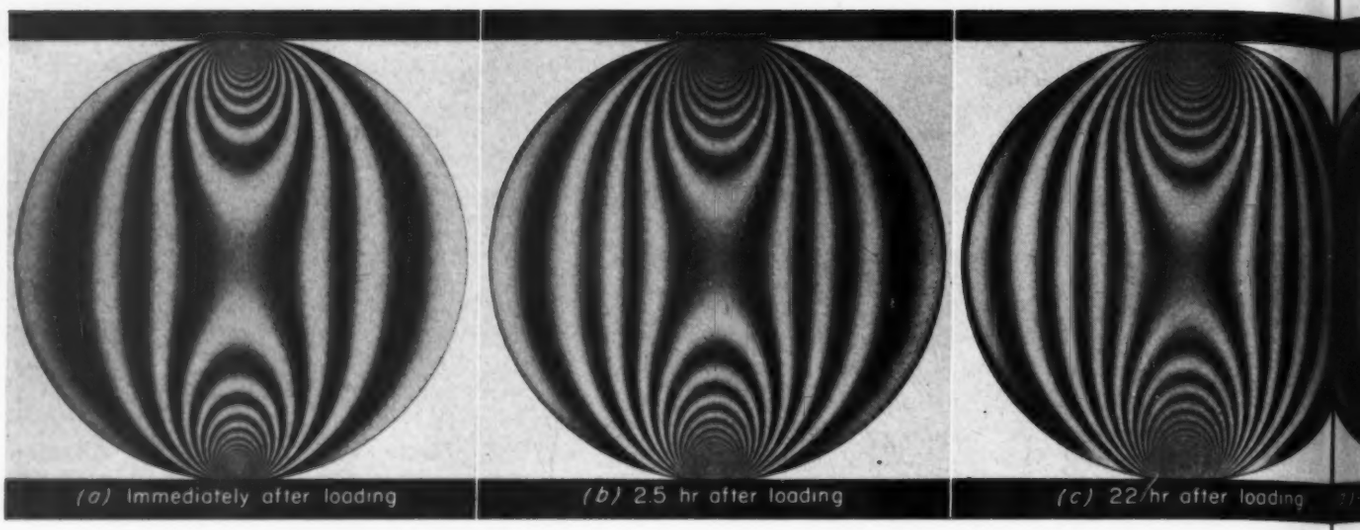


Self-powered automatic control, right, for gas-fired heating plants generates its own electricity to operate the relay-controlled diaphragm valve illustrated. This control system, developed by Minneapolis-Honeywell Regulator Co., is based on the principle of current generation when two unlike metals, joined at one end, are heated. The Powerpile employs 25 such thermocouples and generates 400 to 500 millivolts although the system will operate safely on an output as low as 200 millivolts. The thermostat used in the system is bellows-actuated and uses a mercury switch to eliminate the possibility of dust or oxidation impairing the efficiency of the thermostat. A self-contained polarized relay is employed in the valve for added power. A pilot burner is utilized in the system and, in case of gas supply failure, the entire system shuts down automatically.

Vibratory ball mill, below, developed at the National Bureau of Standards rapidly and uniformly grinds cotton into particles a few microns in length with little or no oxidative change or contamination of the cellulose. In view of the fact that the mill produces a uniform powder and is more efficient than previous devices it is expected to be useful for grinding and blending substances such as pigments, ceramic materials, metal powders, resins, and animal tissues. In this mill a cylindrical jar, suspended by leaf springs, contains steel balls in contact with the material to be ground. The jar is swung through a circular path while being rotated slowly. Motion of the jar is produced by a horizontal shaft connected to a motor at one end and an eccentric weight at the other. Rotating at a speed of 1800 rpm, the weight drives the weight housing in a circular path that is confined within certain limits by the flexural resistance of the springs. The jar containing the sample is held in a cylindrical holder which is attached to the weight housing by a greased slip ring. A small difference in diameter between the flange of the jar holder and the slip ring groove permits the holder with the clamped-in jar to be rolled around the groove circumference by centrifugal force. This rotation takes place at a rate of about 4 rpm in a direction opposite to that of the rotating weight.

In experiments the mill reduced 5 grams of cotton in 30 minutes to particles 10 microns or less in major dimension. X-ray diffraction measurements showed that the cellulose was converted almost completely to the amorphous form.





Three-Dimensional Photoelasticity

. . . new creeping method overcomes limitations of conventional freezing technique

By A. J. Durelli and R. L. Lake
Research Engineers
Armour Research Foundation
Chicago, Ill.

CREEP in plastics is being utilized in a new method of studying distribution of stresses and is promising to be an extremely useful tool for the stress analyst. The common way of studying three-dimensional states of stress by means of photoelasticity is to "freeze" the stresses in a plastic model. Essentially this freezing method requires that the loaded model be heated to about 200 F for several hours. The temperature is then reduced slowly and the model unloaded and sliced. Each slice shows a permanent photoelastic effect, corresponding to the elastic distribution of stresses which was present in the model when loaded. This conventional method has several limitations, the two most important being the need of an oven with precise temperature controls and the large permanent change of shape of the model during heating. The latter occurs because the moduli of elasticity of the plastics used decrease at high temperatures much faster than their optical sensitivities increase.

Freedom from mechanical and optical creep has long been one of the specifications of a good photoelastic material. Research conducted at Armour Research Foundation last year on the creep nature of some photoelastic materials shows, however, that creep when properly used may be an advantage instead of a shortcoming.

The material studied was Catalin, a water-clear transparent phenol-formaldehyde casting resin. In Catalin, at room temperature and stresses up to about 1000 psi (tests have not yet been carried beyond this limit), optical creep is linearly proportional to stress. The importance of this simple optical creep law may be appreciated by looking at *Fig.* 1, where fringe patterns of a disk under diametral compression are shown. The first photograph was taken immediately after the disk was loaded, and subsequent ones at different intervals after loading. The last photograph shows the stress pattern, due to creep, which remained in the disk after the load had been removed. The graph in *Fig.* 2 shows the change in fringe order (maximum shear) for points on the horizontal axis of the disk, as a function of time. Everything happens as if the only thing that changed with time was the fringe value or optical sensitivity of the material. Despite creep, all fringe patterns, including

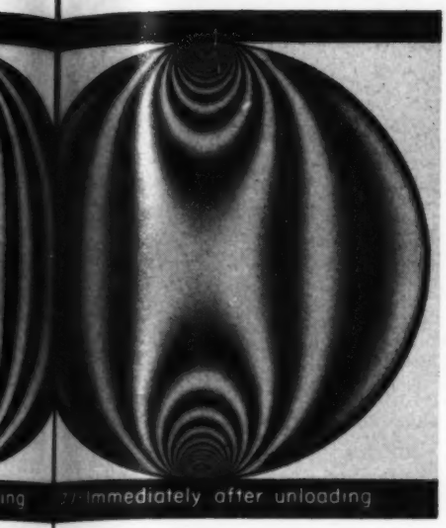


Fig. 1—Above—Effect of time on photoelastic fringe patterns in a Catalin disk under constant load. Residual stress due to creep when model is unloaded is also shown

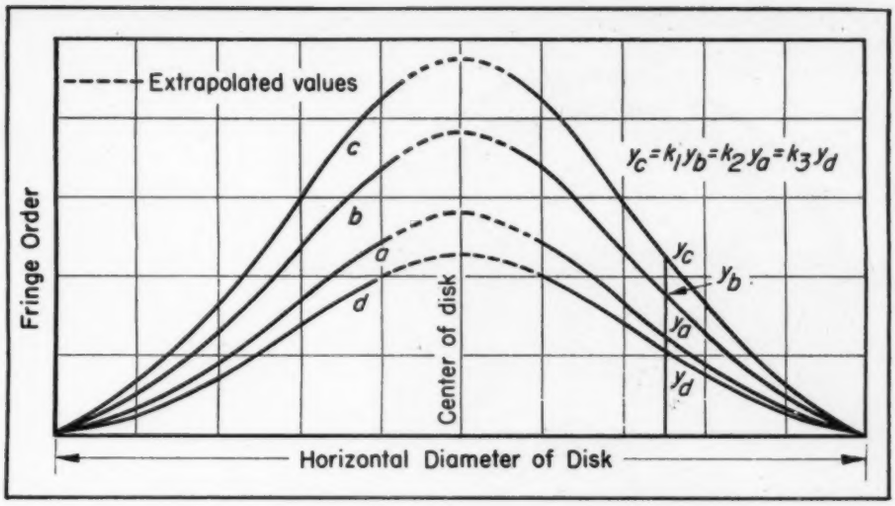


Fig. 2 — Above Right — Creep in Catalin under constant load. The fringe value or optical sensitivity changes but is a function of time only. Curve (a) is for fringe order of disk in Fig. 1 immediately after loading; curve (b) for 2.5 hr after loading; curve (c) for 22 hr after loading; curve (d) for immediately after unloading

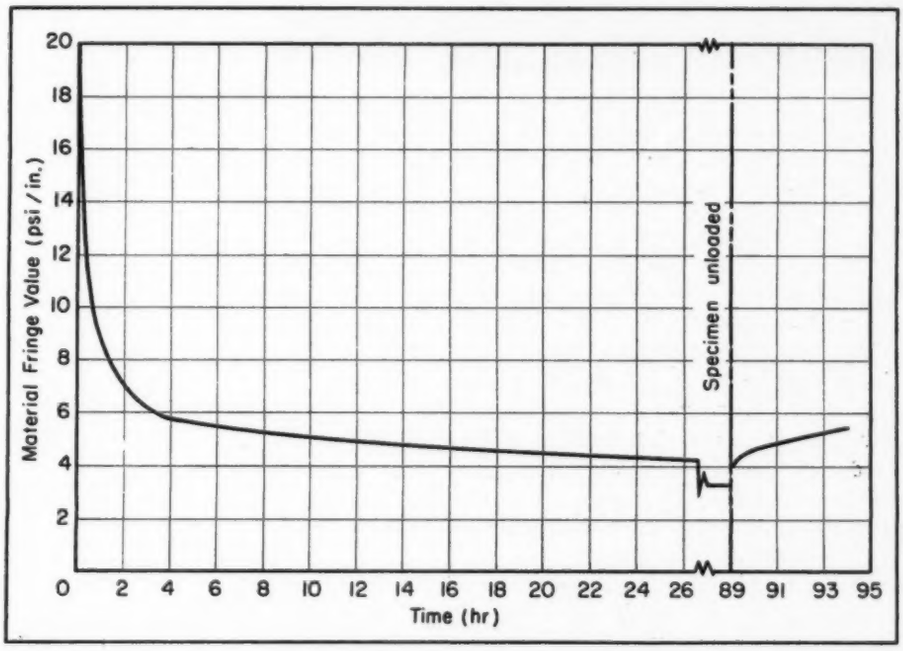


Fig. 3—Right—Fringe value as a function of time for Catalin under constant load

Fig. 4—Right Below—Cylindrical shaft with deep hyperbolic notch under pure tension

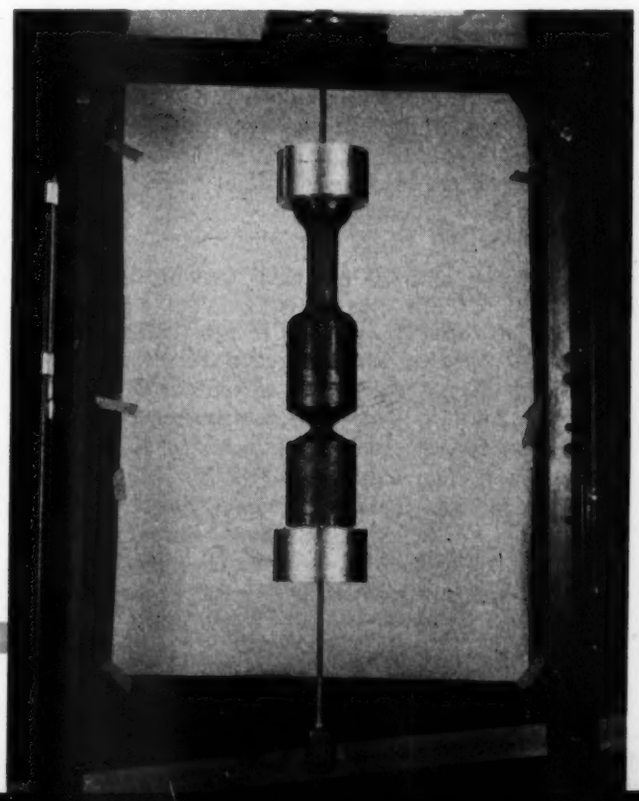
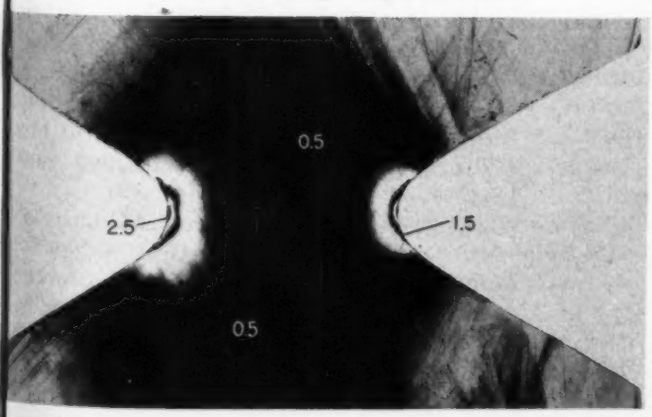


Fig. 5—Below—Light field isochromatic pattern of axial slice, showing fringe order



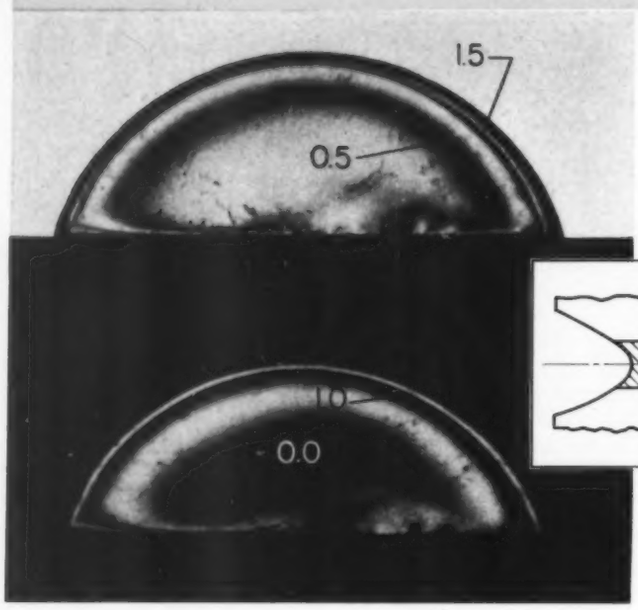
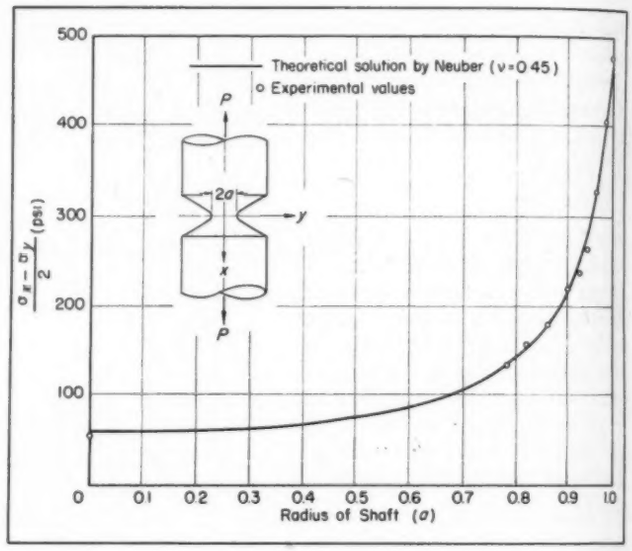


Fig. 6—Left—Isochromatic patterns of a portion of slice containing transverse section of symmetry

Fig. 7—Below—Maximum shear stress, ½ ($\sigma_x - \sigma_y$) for transverse section of symmetry of a circular shaft with a deep hyperbolic notch under pure tension



the last one, correspond to an elastic distribution of stresses.

This remarkable property can be used to advantage in two-dimensional photoelasticity, as a means of increasing the optical sensitivity of the material, as long as the correct fringe value is used to interpret the picture. When the material does not creep, the fringe value is constant. When the material creeps, the fringe value is a function of time, *Fig.* 3.

Usually it is not neecessary to know the fringe value of the material because computations can be made by taking as standard a point in the model where the stress is known. The stresses are given then in ratio form as nondimensional factors, indicating stress distribution.

The extent and permanence of the residual patterns remaining in the disks discussed, *Fig.* 1, suggested the possibility of substituting a period of loading at room temperature for the usual stress-freezing technique which involves cooling under load. Such a method, if proved satisfactory, would eliminate the need for a large oven with precise temperature control and would require no more time than the conventional technique, because the time under load at room temperature would be no longer than the time required for cooling a model from its critical temperature.

Agrees with Theoretical Calculations

To check the validity of the new method a cylindrical shaft with a deep circumferential notch of hyperbolic form, subjected to pure tension, was chosen. Both the theoretical solution of H. Neuber[1] and the photoelastic solutions of M. M. Leven[2] were available for comparison.

The model was machined from a block of Catalin 4 by 4 by 18 inches which had been annealed by holding at 165 F for 4 hours and cooling slowly. Its general form is apparent in *Fig.* 4 which shows it under load. Machining was done at a relatively low speed since the model had a tendency to sag under its own weight when the lathe was stopped and the resulting unbalance produced severe whipping at high speed. All machining cuts were 0.010-inch or less. The notch profile was obtained by machining to a template and consequently could not be held to the exact mathematical shape intended. The a/ρ ratio of the finished notch (where a is the radius of the section and ρ is the radius of curvature at the root of the notch) was found to be 3.9 rather than 4. The cylindrical reduced section was included for the purpose of obtaining an autocalibration. The load which totaled 383 pounds was applied for five hours through threaded caps containing ball joints.

Slicing was done with a wet cutoff wheel mounted on a large surface grinder. The light field pattern of the axial slice is shown in *Fig.* 5 while one section of the transverse slice through the root of the notch is shown in *Fig.* 6. The thickness of the axial slice in *Fig.* 5 was 0.031-inch at the root of the upper notch and 0.046-inch at the root of the lower notch. A certain amount of bending occurred while the model was being sliced, and it was necessary to elim-

[1] References are tabulated at end of article.

Fig. 8—Right — Distribution of stress σ_u along the surface of notch in circular shaft under pure tension

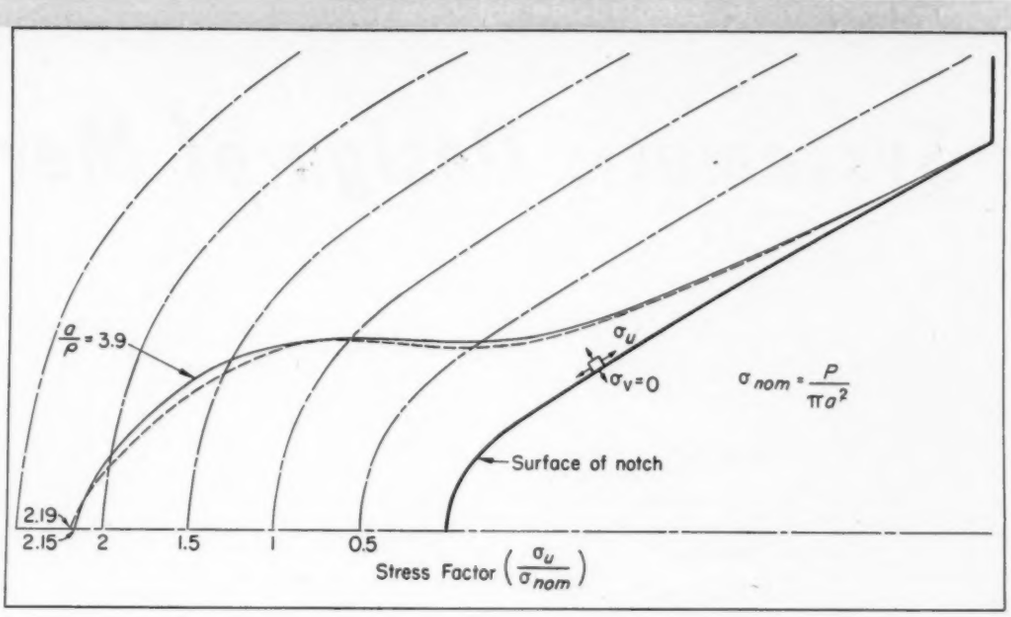
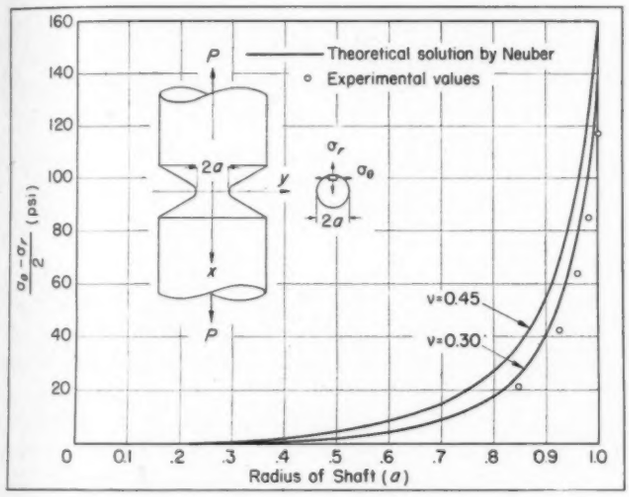


Fig. 9 — Below — Shear stress, $\frac{1}{2}(\sigma_\theta - \sigma_r)$ for transverse section of symmetry



inate bending stress from the computation by averaging the results of the two sides of the slice. The average value of stress at the root of the notch was found to be 2.19 times the nominal stress on the reduced section as compared with a theoretical concentration factor of 2.15 for a notch with an a/ρ ratio of 3.9. Other examples of agreement with the theoretical values are shown in *Figs.* 7 and 8. It will be noted that the experimental values are always within 10 per cent of the theoretical ones. In those cases where the disagreement is greater than 5 per cent the absolute errors are small. There is little doubt that more experience in slicing large models will permit improvement in the attainable precision.

Experimental stress distribution in the transverse plane at the root of the notch together with the corresponding theoretical distributions computed for two values of Poisson's ratios are showing in *Fig.* 9. The lack of agreement probably can be explained in a large measure by the fact that the slice used was 0.154-inch thick. Both the magnitude and direction of the principal stresses change in such a way that the mean shear stress through the slice is less than the value in the central plane. This figure also illustrates a point which some photoelasticians are prone to forget; namely, the possible strong dependence of stress on the elastic constants in three-dimensional problems. Here the shear stress at $0.7a$ increases almost 70 per cent when Poisson's ratio, ν, increases from 0.3 to 0.45. At the surface the percentage increase is down to 17.5 which is still important.

It is believed that this data is sufficient to demonstrate the validity of the creep-freezing method for those cases in which boundary conditions do not change during the course of the test. The technique is certainly not complete as yet. It is necessary to make a further study of calibration techniques since the autocalibration method may not be as practicable in many three-dimensional cases as it is in two dimensions.

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2. M. M. Leven—"A New Material for Three-Demensional Photoelasticity", *Proceedings SESA,* Vol. VI, No. 1

"In scanning the available means to reduce costs—an essential step if markets are to be broadened during the coming year—it appears there is still room for improvement in direct productivity, but from now on research and development will play an increasingly important role in effecting greater distribution of product within the framework of our national wealth. The competition in research and development may prove to be a sad eye-opening experience for those firms still under the impression that they have adequate research departments simply because the name research is printed on the door. Companies in which research is a vital part of management planning are the ones most likely to expand and prosper, the others may experience difficulty in maintaining healthy growth"—W. S. Richardson, *president, B. F. Goodrich Chemical Co.*

Systematic Design of Mechanisms

By H. Ziebolz
Vice President, Engineering
Askania Regulator Co.
Chicago, Illinois

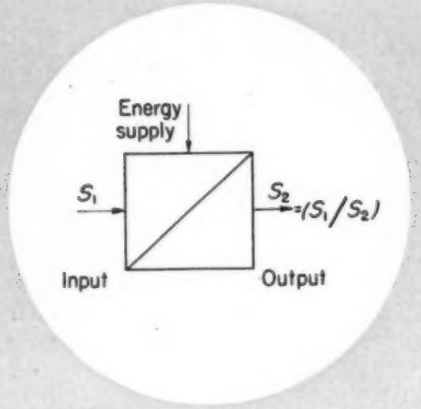


Fig. 1—Any mechanism may be represented by block symbols. In this block, auxiliary power amplifies an input to give the desired output

IN GENERAL, any mechanism may be considered as a "translator" with a certain input and a corresponding output. This design concept was discussed in a previous series of article[1, 2, 3]. Likewise, any physical parameter can be used as an input and any or the same parameter as the output. At that time symbols were established to identify such translators, *Fig.* 1, and a general reference "translator map" was drawn to be used as a filing or reference system for parameters frequently encountered in the design of mechanisms, *Fig.* 2.

In working with these concepts it was soon found that there was a need for an additional group of symbols to represent special types of translators. This type of translator or mechanism has two or more inputs subject to a modification through the device which produces an output representing a mathematical operation performed on and with the inputs. Such a translator is called an "operator" for the purpose of this analysis.

As an example, a lever, a mass or a scale subject to a number of forces acting upon it produces an output, i.e., a force or an indication which is the sum total of all the force inputs. Such an operator performs the function of summarization and is called a summarizer. Other mathematical operations are performed by means of other operators.

In order to systematize the approach, a map similar to that for the translators can be drawn to establish a definite reference place for any particular operator as shown in *Fig.* 3. Each operator is assigned an arbitrary letter and every parameter a subscript numeral. Thus F_3 is the map designation for a force splitter. In *Fig.* 4 are tabulated each of these operators, showing their mathematical functions and corresponding symbols which are to be used in a block diagram describing any device in question. *Fig.* 4 appears to be self-explanatory with the exception perhaps of the last column which introduces the concept of a "splitter".

A splitter is an operator which has one input parameter and several output parameters representing the *same* variable of the same magnitude or of any fixed ratio to the input. A typical example of such

SYSTEMATIC DESIGN aids the designer in developing or analyzing any mechanism in terms of operation or function. This fundamental approach simplifies and organizes the designer's work like a schematic diagram aids an electrical engineer. It catalogs all known mechanisms for ready reference and provides for future devices to be developed. By such a systematic study a designer can substitute equivalent mechanisms, obtaining more suitable characteristics, greater accuracy, more dependable operation, or lower cost

[1]References are listed at end of article.

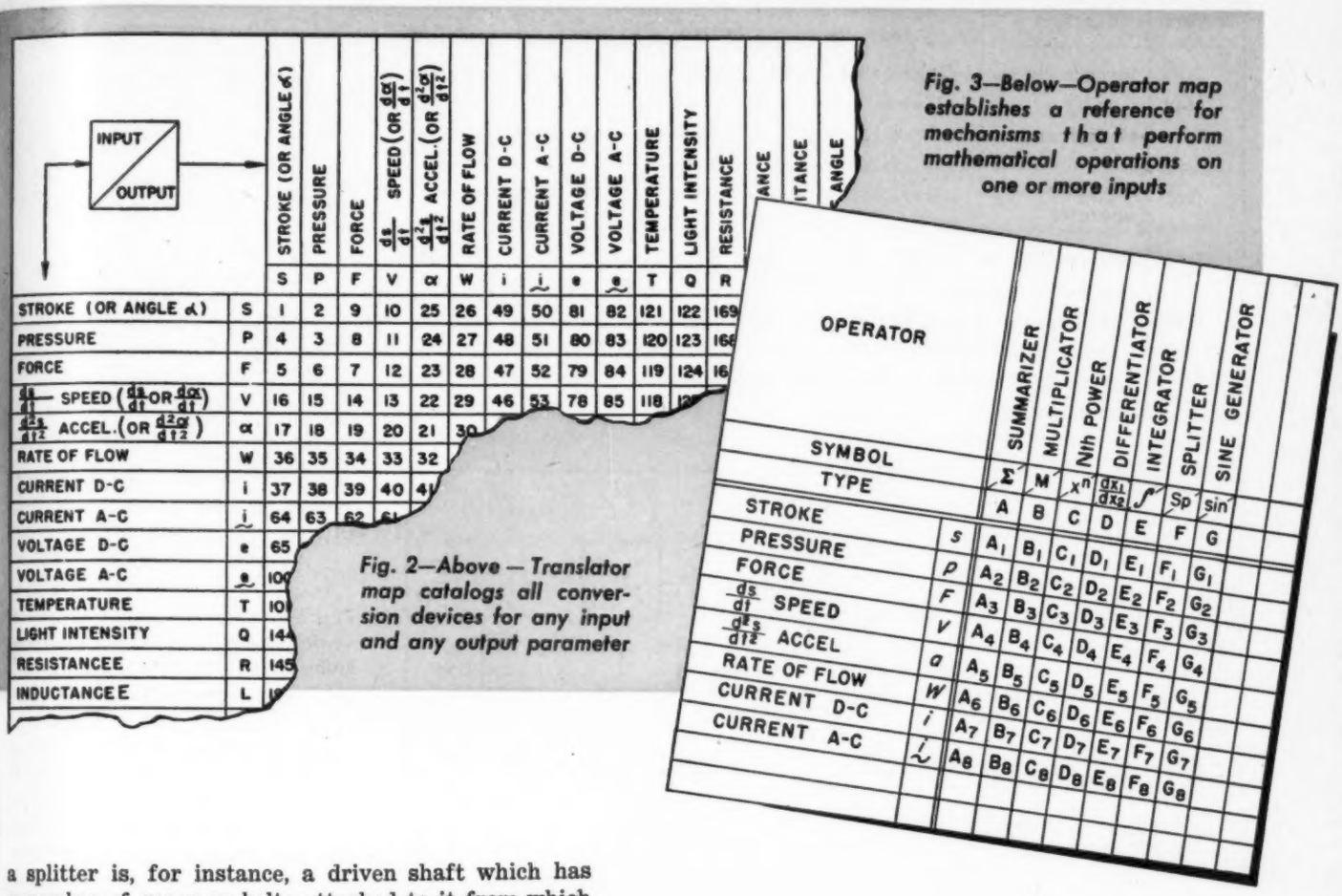


Fig. 3—Below—Operator map establishes a reference for mechanisms that perform mathematical operations on one or more inputs

Fig. 2—Above — Translator map catalogs all conversion devices for any input and any output parameter

a splitter is, for instance, a driven shaft which has a number of gears or belts attached to it from which other devices are deriving their power or motion, *Fig.* 5. Another example is a pressure header which has a number of outlets.

One can think of a splitter best as a device which permits the branching of parallel circuit elements. Series operation of translators on the other hand are indicated by a chain arrangement of individual blocks connected by plus signs.

With these symbols and concepts, it is possible to describe any desired circuit or mechanism. In *Fig.* 6, for instance, a device is shown which is an overall translator (x_1/x_2) with an input x_1 and an output x_2. The input x_1 is first subdivided or split into two branches, x_3 and x_4. Further the first output x_3 is multiplied by means of a multiplicator M, then twice integrated through a series circuit. This output is added to x_4 and to the rate component of x_2. The important feature of this symbolic block diagram is the fact that it not only gives the overall circuit, but also the operation or function of each component.

In order to avoid the necessity of drawing a circuit as shown in *Fig.* 6, it is possible to describe this same circuit by the following pseudo equations:

$$\mathrm{Sp}(x_1/x_3, x_4) + \mathrm{M}(cx_3) + \int(x_5 dt) + \int(x_6 dt) +$$

$$\Sigma(x_8, x_7, x_4/x_9) + \mathrm{Sp}(x_9/x_2, x_{10}) = (x_1/x_2)$$

$$(dx_{10}/dt/x_7) = (x_{10}/x_7)$$

At this point it appears desirable to give some typical examples of operators. Surveys show that certain operations can be performed more easily with certain types of parameters than with others. For instance, there are a number of devices available for summarization[4]. On the other hand, there is so far no device or operator known which permits direct summarization of pressures. Absence of such a device forces the designer to first translate pressures into other parameters for which summarizers are available—forces, voltages, currents, etc.

Types of Operators

SUMMARIZERS: In surveying summarizers it is logical to start with mechanical devices, the oldest known to man. The earliest summarizer of forces most likely is the scale or lever which needs no further explanation, *Fig.* 7. For the summarization of strokes the same lever can be used with the addition of multiple links, *Figs.* 8, and 8*a*.

For summarizing rotary motion differential gears of various designs are used. The one shown in *Fig.* 9 is of interest because it uses a new development in gear design. It permits the elimination of the conventional bevel gear spider, thereby reducing backlash to an adjustable minimum. In *Fig.* 10 the summarization of strokes s_1 and s_2 produces a corresponding pulley movement s_3 which is the sum of s_1 and s_2. Another often used summarizer for mechanical displacements (angular rotation) is a differential screw in which one motion is introduced into a screw while the second rotation is produced by moving the nut

Operator	Function	Mathematical operation	Symbol	
			Written	Block
A	Summarizer	$\Sigma(x_1+x_2+x_3+\ldots\ldots x_n)$	Σ	Σ
B	Multiplicator	$x_1 x_2 x_3 \ldots\ldots x_n$	M	M
C	Nth power operator	x^n	X^n	X^n
D	Differentiator	$\frac{dx_1}{dx_2}$	$\frac{dx_1}{dx_2}$	$\frac{dx_1}{dx_2}$
E	Integrator	$\int x_1 dx_2$	$\int$	$\int$
F	Splitter	$ax_1=x_2;\ bx_1=x_3;\ nx_1=x_n$	Sp	Sp

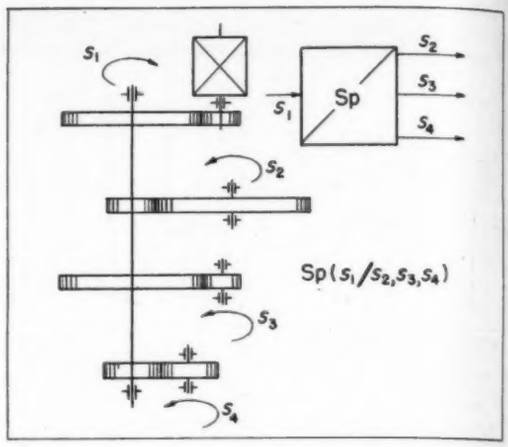


Fig. 4—Above Left—Classification of operators, showing the mathematical operation performed and the symbols representing each

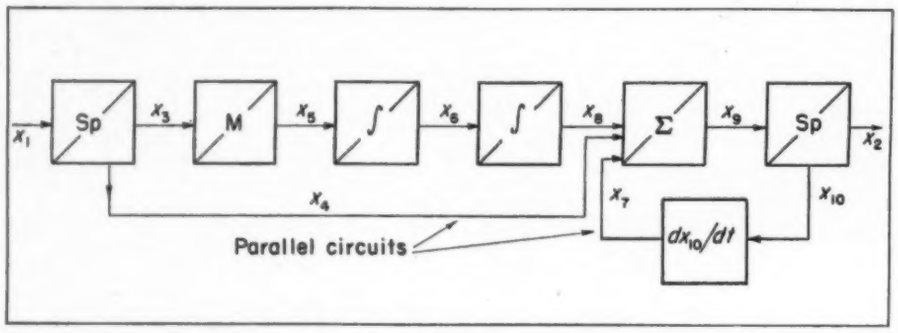


Fig. 5—Above—Conventional representation and symbols for a splitter using a motor drive and take-off gearing in parallel

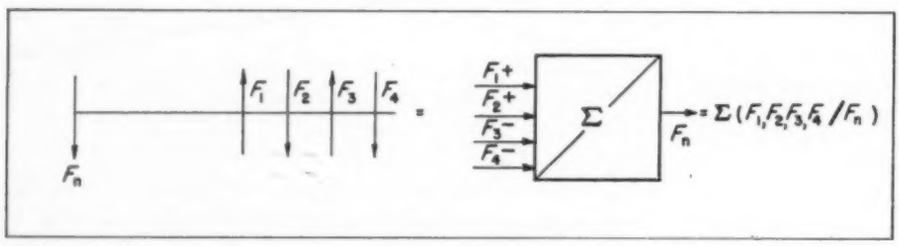


Fig. 6—Left—Overall operator showing how symbols are combined to produce an output from a given input. Two splitters, one multiplicator, two integrators, one summarizer, and one differentiator are employed in the system

Fig. 7—Left — Diagrammatic representation of a force summarizer showing its equivalent block and written symbols

which in turn acts as a screw, *Fig.* 11.

Because of the general increase in use of electrical devices, a number of circuits have been developed for summarizing electrical signals. Most common circuits are for summarizing either voltages or currents, *Fig.* 12. In this circuit i_1, i_2, i_3, i_4 represent individual current across the corresponding resistors R_1, R_2, R_3, R_4. As all branches finally join into one branch,

$$i_t = i_1 + i_2 + i_3 + i_4 = \Sigma i_n$$

or the voltage drop of e_r across the resistor R gives an indication of the sum total of all currents. In order to use this basic circuit it is therefore necessary only to translate the individual variables into corresponding currents by means of suitable translators taken from the translator map.

In industrial control applications, a general problem involves blending or summarizing flows. Obviously, the simplest form of summarization for liquids and solids is a common duct or vessel into which these elements are delivered. In many applications, however, an indication is desired to give the sum total of all flow rates at a given moment. Because liquids usually cannot be added in such cases, it becomes necessary to translate each individual flow rate into another parameter (current, voltage, force, airflow, etc.) which can then be conventiently summarized to produce an output (signal), representing the sum total of all flow rates.

System Would Develop All Circuits

Patent literature covering devices of this type indicates that a systematic approach to the solution of this problem would have produced all of the separately patented circuits and a considerable number of additional ones[5]. As a matter of fact the analysis of these devices by the author finally led to the development of this systematic method of approach.

Obviously the applications discussed here by no means exhaust either the mechanical or electrical devices available for summarization. They are given as illustrations rather than as a reference book of ready-made solutions. Some typical or unusual examples of other types of operators will be discussed in the same manner.

MULTIPLIERS: Starting again with mechanical solutions for multipliers, *Fig.* 13 shows details of a mechanical multiplier which is visible as part of the

H. ZIEBOLZ—in charge of engineering and development of servo-mechanisms and instrumentation for Askania's industrial control division, special devices for the Armed Forces, and industrial special devices—has been active in the design of hydraulic regulators and servos for more than twenty years. During World War 2 his main efforts outside the field of controls for industry were concerned with submarine trainers for the Bureau of Ships. During a trip to Japan in 1934 he started his work on systematic design. His first paper on the subject was delivered in 1942 at the Gordon Conference of the American Association for the Advancement of Science. During the same year he published *Relay Devices and Their Application to the Solution of Mathematical Equations.* One of the original purposes of his work was to clear the way for the designer through uncertainties in the present patent situation by reducing certain aspects of so-called invention to a systematic approach

assembly of *Fig.* 10. Being an approximation, due to nonlinear displacements, it is best for small values of s_1 and s_2. A better solution is shown in *Fig.* 14 which produces an output (AB) with either A or B varying through respective ranges of ± 10.

For even higher accuracy a device is available which is based on the equations:

$$(s_1 + s_2)^2 = s_1^2 + 2s_1s_2 + s_2^2$$

$$(s_1 - s_2)^2 = s_1^2 - 2s_1s_2 + s_2^2$$

Subtracting the second from the first equation, the right-hand side becomes

$$4s_1s_2$$

The multiplicator, therefore, consists of two summarizers, two 2nd-power operators, and one additional summarizer. It can be represented in the form

$$\Sigma(s_1 + s_2/s_3) + (s_3^2/s_4) = s_5$$

$$\Sigma(s_1 - s_2/s_6) + (s_6^2/s_7) = s_8$$

$$\Sigma(s_5 - s_8/s_9) = (4\, s_1\, s_2)$$

Its remarkable accuracy of 1 in 10,000 with linearity throughout the range makes this device ideal for precision computers. Incidentally, the same principle is used in electronic analog computing circuits to produce the product of two currents or voltages. Other forms of multiplicators translate the variables first into logarithms, summarize as the next step and then reconvert into antilogarithms to produce the product of the inputs.

Division, i.e., the reverse operation, is more difficult in most cases. An interesting solution of a device which uses a servo circuit for division is schematically shown in *Fig.* 15. The equation solved by this device is:

$$s_3 = \frac{s_2}{s_1}$$

In order to obtain this result the first multiplicator has as input s_1 and the unknown result s_3.

Its output is therefore s_1s_3 and is used as one of the inputs of the summarizer whose other input with negative sign is the value of s_2. The summarizer acts as a servo and adjusts itself automatically in such a way that its output is always zero, so that

$$s_1s_3 - s_2 = 0;\ s_3 = \frac{s_2}{s_1}$$

Unfortunately, the problem of division becomes more and more difficult as the denominator approaches zero or as s_2 and s_1 become smaller and smaller.

In the first case, the output becomes infinite which obviously is impractical as the range of computers is limited; in the second case, the device approaches its own noise level or the range of its backlash, and the results become meaningless. In such cases one of the possible remedies is to shift the base line for s_1 or s_2 to avoid going through zero; another is, if possible, to rewrite the basic equation in such a manner that no division through zero is necessary.

Shift May Affect Accuracy

Unfortunately, the shift of zero point has the disadvantage that the accuracy of the result may be seriously reduced. This becomes evident from analysis of *Fig.* 16 which represents a typical example. In this figure the problem is to get the average ordinate in the interval x_1 of the function $y = f(x)$. This average is defined by

$$y_{ave} = \int_0^{x_1} \frac{f(x)\,dx}{x_1}$$

If x_1 is approaching zero, the problem of dividing zero area through zero becomes formidable.

Shifting the zero x_1, i.e., the origin, to the left by a value x_0 avoids this difficulty but "dilutes" the average by the arbitrary addition with the result that

$$y_{ave} = \frac{y_1x_0 + \int^{x} f(x)\,dx}{x_0 + x_1}$$

is not any longer the true y_{ave} needed. This problem

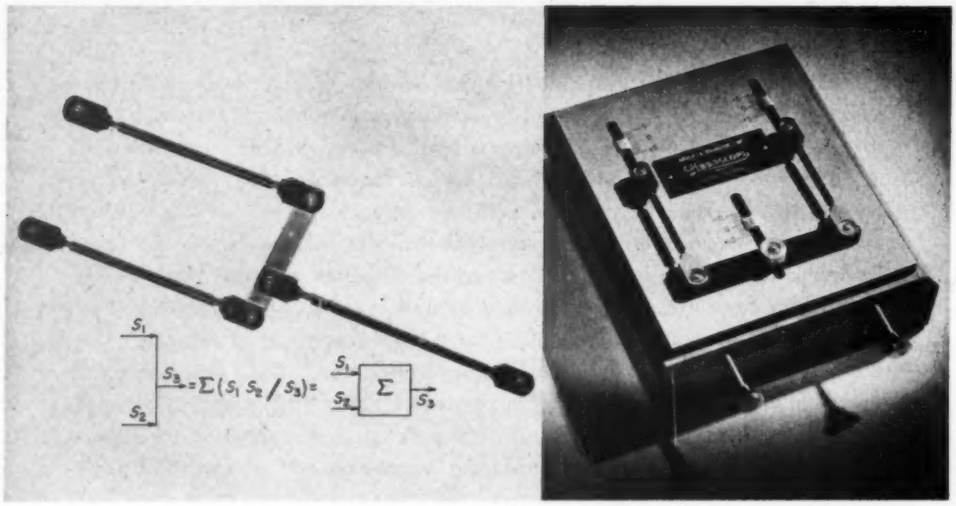


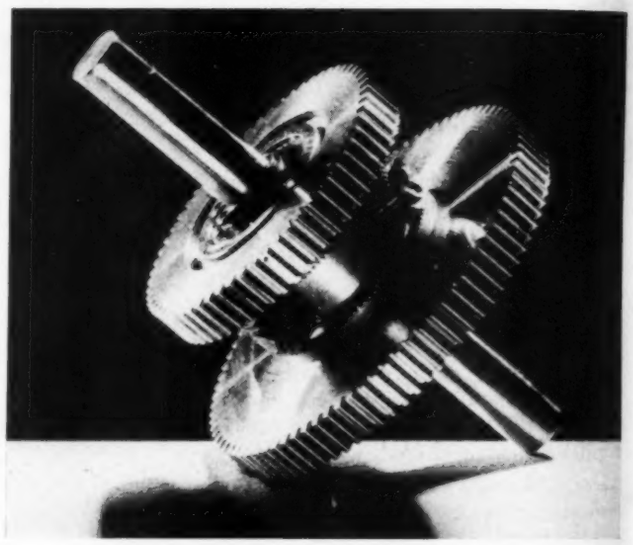
Fig. 8 — Left — Multiple links employed for summing strokes

Fig. 9 — Below — Differential gearing for summarization of rotary motion. Design of this unit reduces backlash to a minimum value

is particularly annoying in the design of a computer which continuously calculates statistical data such as standard deviations or the algebraic mean.

NTH POWER OPERATOR: It is possible to get 2nd, 3rd and higher powers of a parameter by using two or more multiplicators in series and repeating the multiplication with the parameter. Use of such a mechanism has already been mentioned in the discussion of a multiplicator for deducting the square of the sum of two variables from the square of the difference. In *Fig.* 17 a mechanical solution is shown schematically.

This variable-speed drive consists of a disk, two spacer balls, and an output cylinder. It is so arranged that the input x not only displaces the spacer which represents the usual adjustment of a variable-



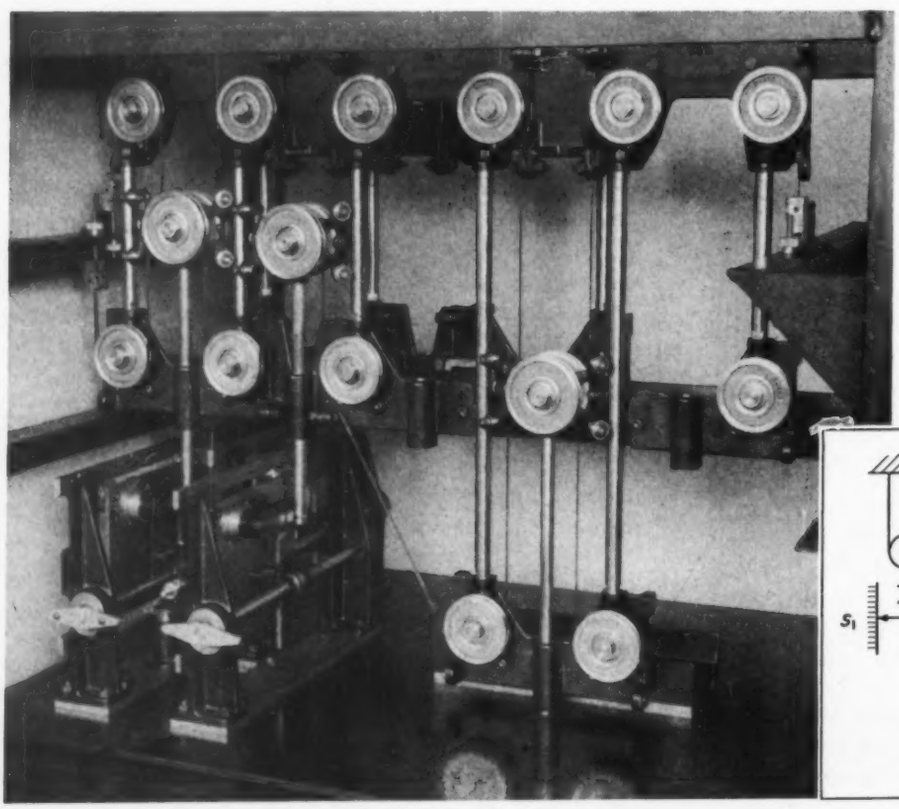
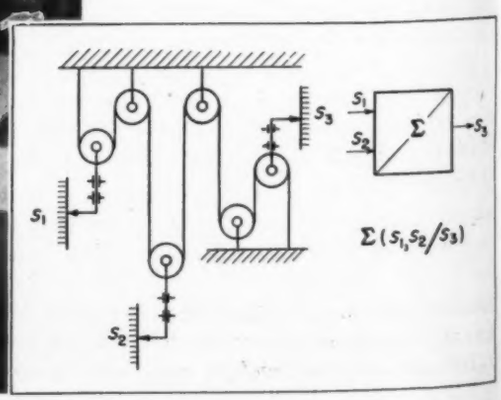


Fig. 10—Left—Cable and pulley system for summarizing strokes. Schematic and block diagram for this system are shown below



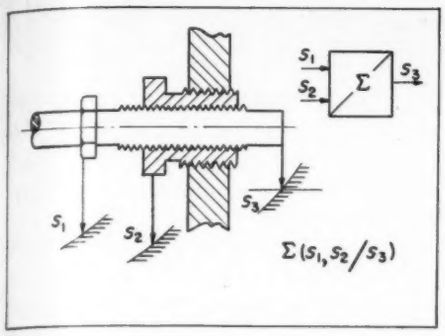
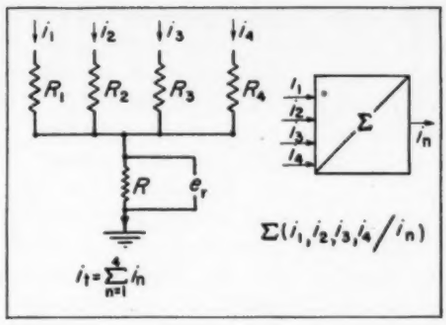
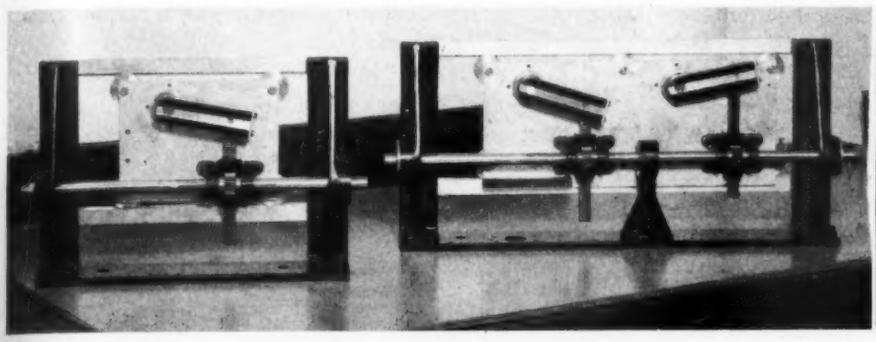


Fig. 11 — Left — Differential screw for summing two rotary motions as inputs

Fig. 12—Right—Circuit representations for summing electric currents





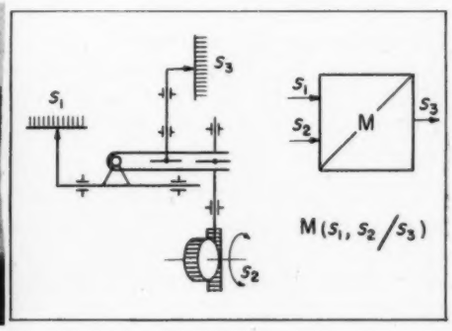


Fig. 13—Mechanical multiplier and its corresponding diagrammatic sketch and symbols

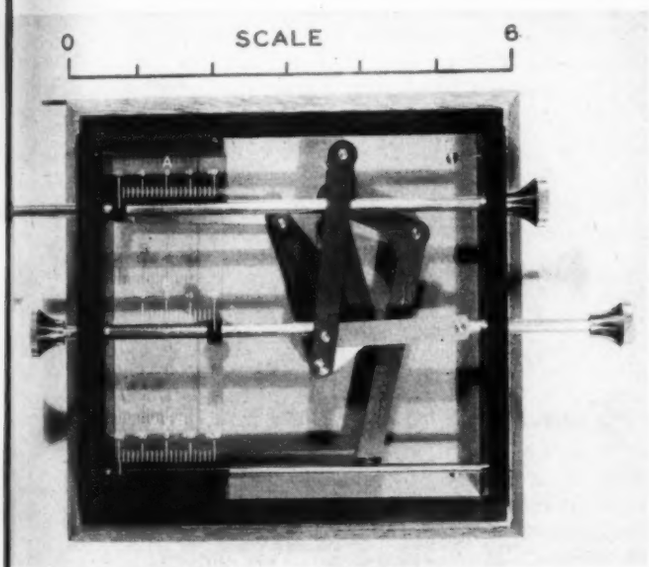
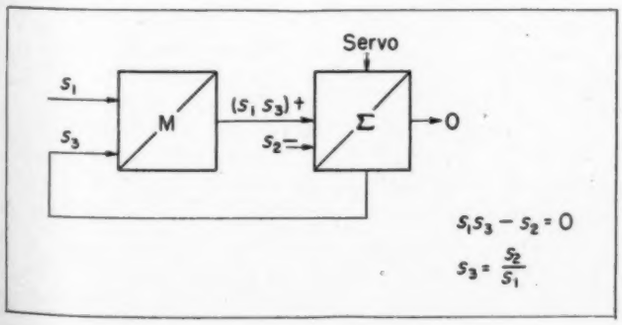


Fig. 14—Linkage arrangement for obtaining the product of two quantities

Fig. 15—Below—Servo circuit for performing division operations, employing a multiplicator and summarizer



speed drive, but also feeds the same variable into the disk drive. With x representing the number of rotations of the disk and also the speed-adjustment factor introduced by the displacement of the spacer, the output becomes x^2.

May Simplify Mechanism

In actual design the variable-speed drive is of a design which avoids any possible slippage by using a cone drive with a positive transmission ratio which changes in direct proportion to the input x. By using forces instead of displacements as the parameter it is sometimes possible to simplify the mechanism. In *Fig.* 18, for instance, the desired output pressure times area or force is to be the 2nd power of the input which happens to be the rate of rotation of a shaft. A centrifugal governor attached to the shaft gives the desired output because centrifugal force of a rotating mass changes with the second power of the speed of rotation. The translator which is added in series to translate this force into pressure is secondary and not essential for the purpose of this discussion.

If electrical parameters are available for the input, such as currents, the attraction of two current coils which produce a force F becomes

$$F = ci_1i_2 \text{ or } F = ci^2$$

This relationship can be and has been utilized to get second powers of currents.

Likewise, in fluid-flow measurement problems, the differential pressure obtained across a restriction varies with the square of flow rate W. This relationship is frequently employed, to obtain second power functions of the parameter W into which other para-

meters can be translated as desired.

In *Fig.* 19, the basic principle in *Fig.* 17 is applied to a series arrangement of two multiplicators translated into an electric circuit. The first potentiometer multiplies the voltage with a factor x while the second multiplicator potentiometer multiplies the result again with the same factor. Both potentiometers are ganged, i.e., their shafts are mechanically connected.

Other frequently used methods are translation of the variable into its logarithm, multiplying this logarithm with the factor representing the power and then retranslation of the output into the antilogarithm. For these two steps of translation either cams or, with electrical circuits, specially wound potentiometers are used. In electronic circuits, tubes are employed having characteristics approximating logarithms. One frequently used approximation of logarithms is a hyperbolic function within the limited range of 2:05 to 1:05.

DIFFERENTIATION OR RATE DEVICES: There is general need for reliable and simple rate devices covering wide ranges of rates or time scales. Theoretically, the best approach is that offered by the rate gyro which produces a precessing moment or force directly proportional to the rotation rate of the axis of the gyro, *Fig.* 20.

By adding a force-stroke translator, e.g., a spring, the displacement s of a pointer becomes directly proportional to the rate of rotation ds/dt. Other translators for the precession force produce directly proportional currents or pressures.

Another type of rate indicating device is based on the addition of a rate vector which is unknown in magnitude to one which is known but 90 degrees displaced. The resultant vector produces an angle relative to the known vector which is a function of the rate vector to be measured. The design element employed for this device is a roller mounted slightly eccentric to a rotating axis. Like the idle wheel of a single-wheel trailer or the tail wheel of an airplane, its circumference will always adjust itself to the tangent of the path of the vehicle, *Fig.* 21. An experimental rate indicator of this type is shown in *Fig.* 22.

Speed of the cylinder v_2 can be varied to change the proportionality factor, i.e., the sensitivity factor of the relationship

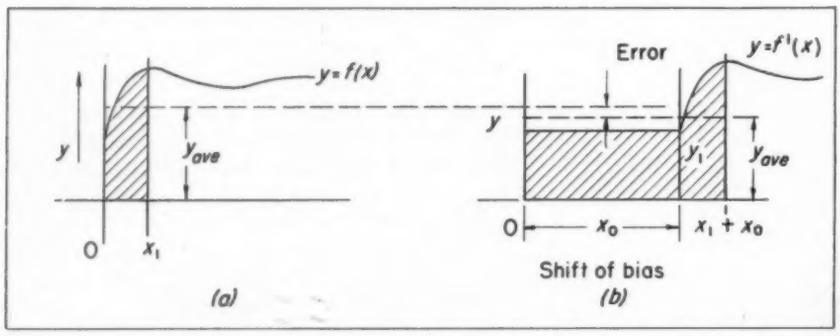
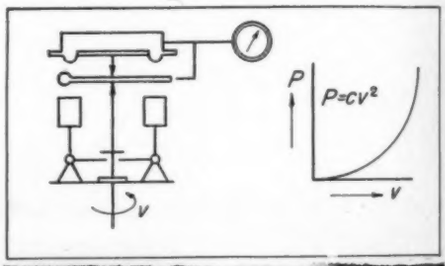


Fig. 16—Above—Graphical representation showing the error introduced by shifting the origin to avoid approaching zero values



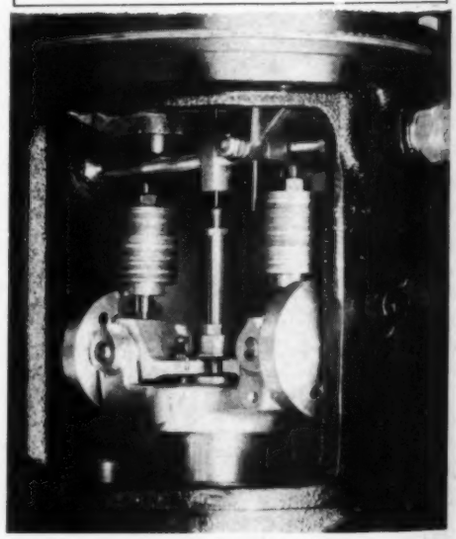


Fig. 17—Below—Mechanical solution for squaring a quantity, utilizing a variable-speed drive

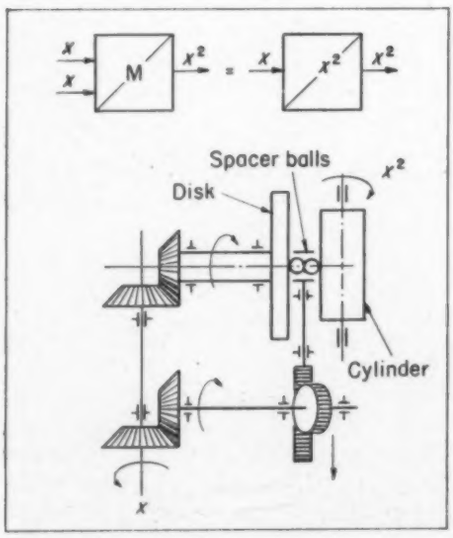
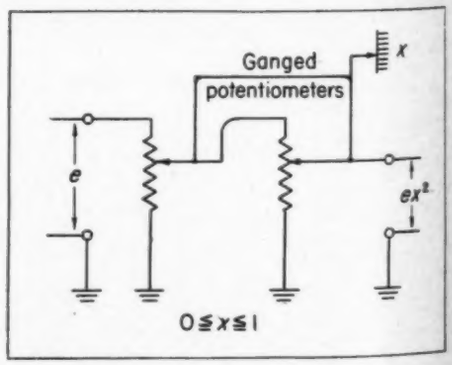


Fig. 18 — Right — Centrifugal force of a rotating mass, being proportional to the square of the speed, is used in this device to obtain the square of the shaft rotation

Fig. 19 — Right — Ganged potentiometers multiply voltage to obtain the second power of a quantity



$$\tan \alpha = \frac{v_1}{v_2} = cv_1$$

where the constant c equals $1/v^2$ as derived from the geometry of the vector diagram in *Fig.* 21.

Often a value approaching the derivative is obtained from the difference of an input signal and the output of a delayed follow-up servo system. In simple form, one possible solution uses mechanical components only, *Fig.* 23. The input here is s_1. This input is applied to the summarizer in *Fig.* 23 at point *A*. With *C* stationary, point *B* is thereby displaced and changes the output rate of the variable-speed device.

This moves point *C* at a rate ds_2/dt in a direction to return the point *B* (negative feedback) into its neutral or zero output-speed position. With s_1 continuing to feed at a rate ds_1/dt, point *B* will be displaced by a proportional amount $s_3 = ds_1/dt$. Therefore, s_3 can be used to indicate the input rate ds_1/dt. A translation of the mechanical variable-speed drive into its hydraulic equivalent changes only design details but not the basic approach, *Fig.* 24.

Electrical Circuit Is Equivalent

Going one step further and realizing that the rate signal thus obtained is due to the delay in the feedback or equalizing action of the variable-speed device (or integrating type, as will be shown later) one can draw an equivalent electrical circuit as shown in *Fig.* 25. The condenser will charge at a rate which is proportional to the rate of the applied voltage e_1. Voltage e_3, like s_3 of *Fig.* 24, is an indication of this charging rate.

Another mechanical rate indicator, similar to *Fig.* 22, is based on comparing a vector of known magnitude with one whose amplitude is to be measured, *Fig.* 26. Here the incoming vector (rate of rotation) ds_1/dt becomes the input of a differential gear. A servo loop is added in such a way that ds_3/dt is reduced to zero.

Circuits Are Identical

This requires a displacement s_4 of the variable-speed drive, and this displacement is the value representing the magnitude of the input rate $ds_1/dt = cs_4$. A closer analysis of the circuits in *Figs.* 23 and 26, will show that the two circuits are identical although the philosophy of approach is different in each.

INTEGRATORS: In the preceding paragraphs, variable speed devices have been employed several times as integrators, particularly one type which is known as the "ball and disk" integrator. *Fig.* 27 shows such a unit and how the $\int ydx$ is obtained by rotating the disk an amount dx with a displacement y of the ball. Reproducibility of the integral is as high as 0.01 per cent.

Obviously, any other variable-speed drive will serve the same purpose. If dx/dt is constant, representing time, the problem is simplified to one of introducing y only. Variable-speed electric motors may be used as integrators with the input y being fed into the

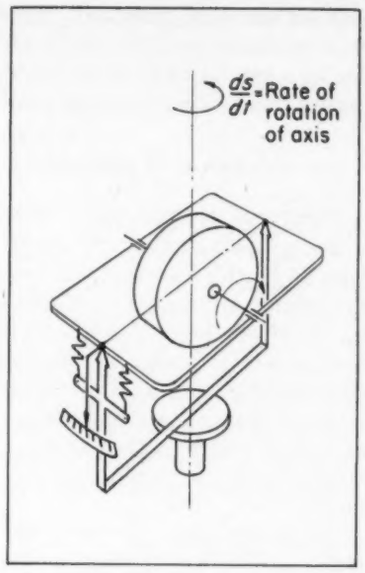


Fig. 20 — Rate gyro has a precessing moment that varies directly as the rotation rate of the gyro axis. Position of the pointer indicates the rate of rotation

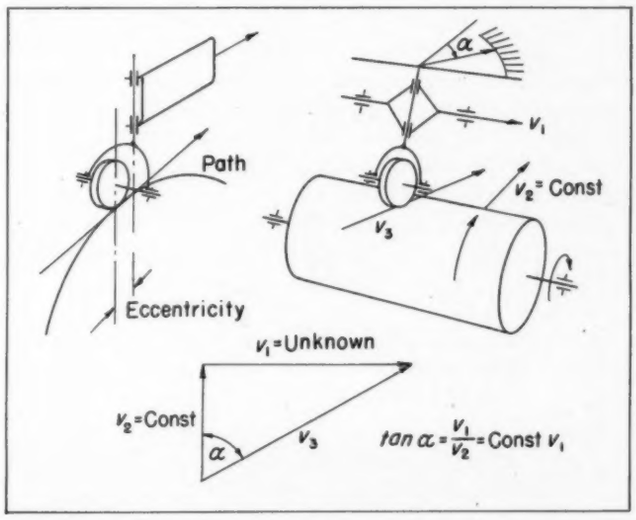
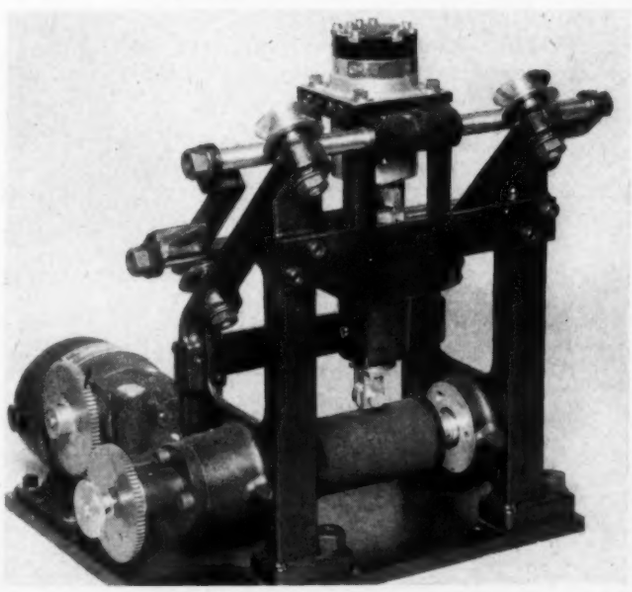


Fig. 21—Rate indicator employing a wheel rolling on a cylinder. Angle of the wheel path is a function of the rate vector to be measured

Fig. 22—Below—Experimental rate indicator employing the principle shown in Fig. 21



mechanism at a constant scanning rate of the function to be integrated. Also, as has been shown, condensers can be used as integrators, assuming leakage across the condensers to be small.

Develops Trigonometric Relationships

FUNCTION GENERATORS: Where the desired output is not proportional to the input, but is instead a function of it, the operator device is known as a function generator. For instance, a sine or cosine function may be required. *Fig.* 28 shows a sine and cosine generator which is based on the fact that a point on the circumference of a circle rolling inside of a second circle of twice its diameter moves on a straight line at a rate which is that of the rotation of the smaller circle times the sine or cosine of its angular displacement.

Cams can also be used to produce these or any other desired relationships between inputs and outputs. There is a whole literature on the subject of cam design[7] and it would go beyond the scope of this study to go into the problem of such design procedure in detail.

One device which avoids difficulties of manufacturing cams employs thin sheet-metal templates. Also, it prevents sticking at points of excessive change of rates of rise and has an additional feature of power amplification. This device is illustrated in *Fig.* 29. It consists of two opposed air nozzles—one supplying and one receiving air—carried by the end of a piston rod of a double-acting hydraulic piston.

This piston is controlled by the constant-pressure regulator shown at the bottom of the unit. As the cam rotates, its circumference moves relative to the receiving nozzle. This varies the pressure in the nozzle and, as a result, the pressure control moves the receiving nozzle in a direction to restore the pressure. Therefore, the two nozzles will always seek the position of coincidence with the rim of the cam. The only contact between the mechanism and the cam is an ⅛-inch diameter air jet. There being no mechanical contact, no load or wear of the cam results in this design.

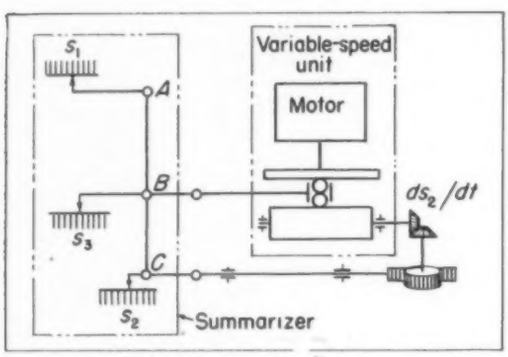


Fig. 23 — Above — Mechanical variable-speed unit employed in a rate indicator

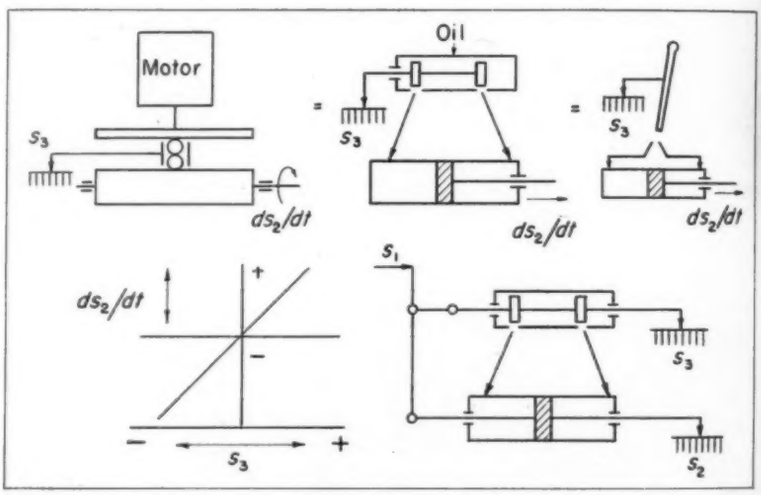


Fig. 24—Above Right—Equivalent hydraulic systems for the mechanical variable-speed unit shown in Fig. 23

Fig. 25—Below—Equivalent electrical circuit for a rate indicator. Measured voltage is an indication of condenser charging rate

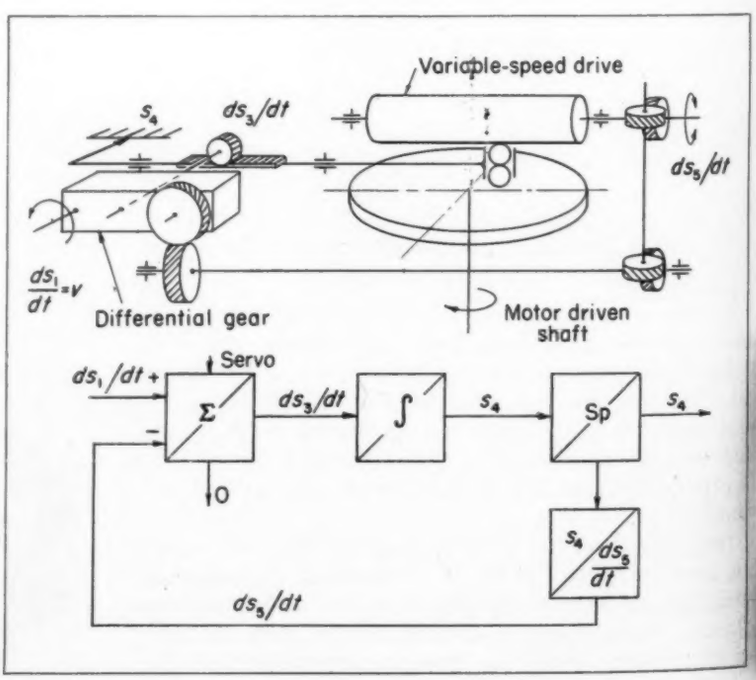
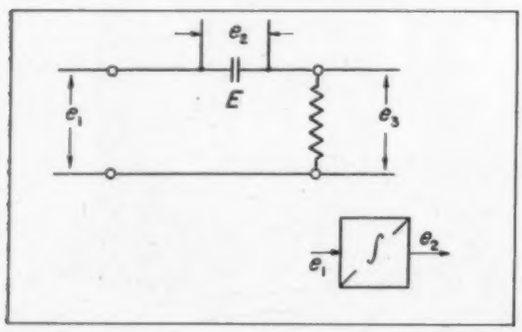
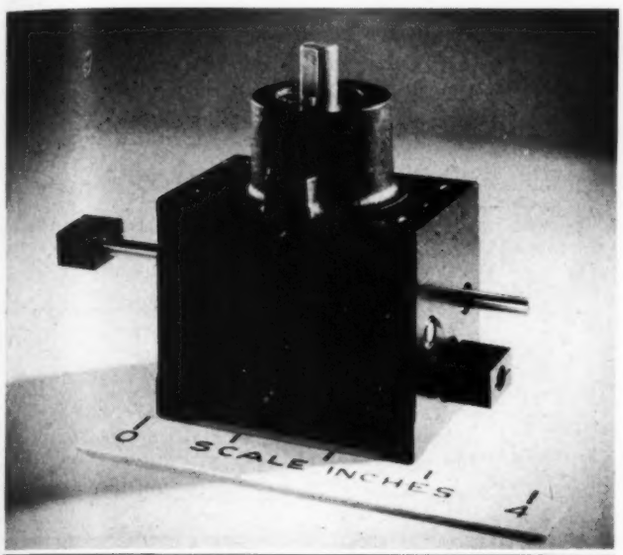


Fig. 26—Right—Mechanical rate indicator, similar to Fig. 22, has a servo loop added



Because it is difficult to produce economically cams of high accuracy for computing mechanisms, another approach has been chosen as illustrated in *Fig.* 30. With this method, it is possible to obtain a great variety of functions as the output of 4-bar linkages of various lengths.

In order to investigate systematically all possible functions, a device shown in *Fig.* 31 was constructed. With this instrument it is possible to match experimentally any desired function with 4-bar linkages and to determine the maximum errors which are introduced by this approximation. The availability of such experimental devices and a general catalog of possible patterns will offer many short cuts to machine and computer designers.



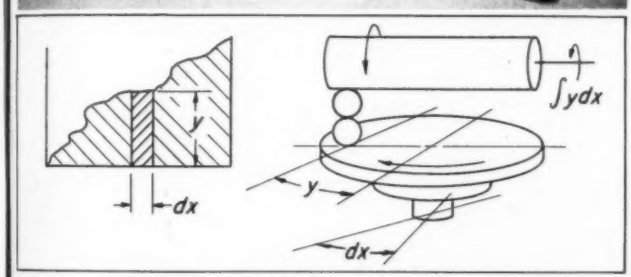
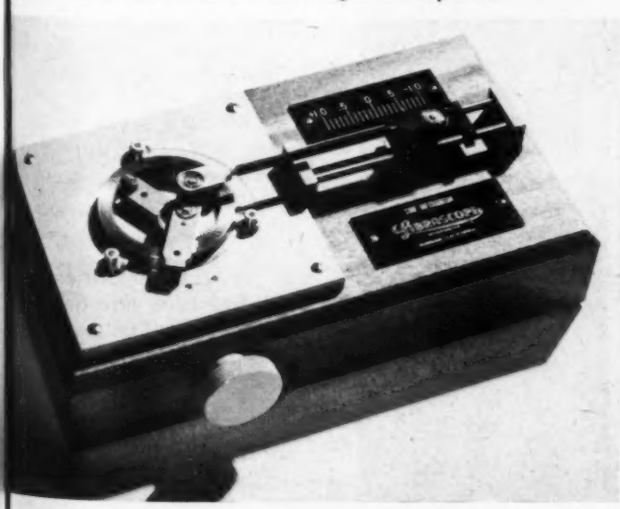


Fig. 27—Above—Variable-speed device using disk, balls and cylinder as illustrated in several previous sketches

Fig. 28—Below—Sine mechanism produces linear motion at a rate proportional to the rotation of the smaller circle and the sine of its angular displacement

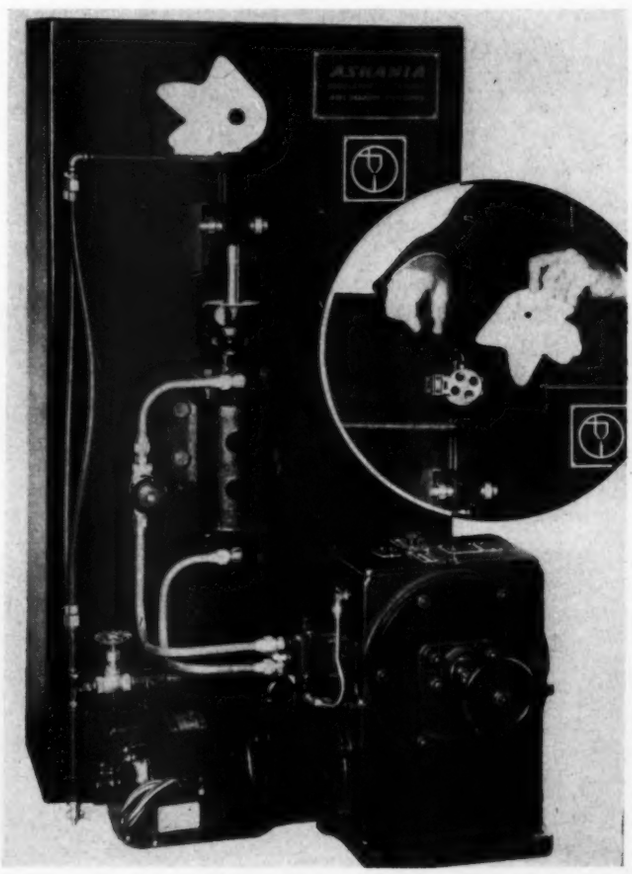


Applications: This analysis has provided a general survey of the concept of operators and translators. By a systematic study of economic considerations and accuracies as well as time constants, availability, and space and service requirements, it is possible to translate designs into equivalent mechanisms with different and more suitable parameters. If, for instance, the basic requirements of a device—computer, regulator, simulator, etc.—calls for many derivatives with low time constants, electrical circuits appear preferable to a pure mechanical solution. They take advantage of simple differentiator and integrator operators.

May Obtain More Suitable Characteristics

In such cases, it may be desirable to translate those parts of the block diagram containing the differentiators into electrical parameters and retranslate the final output of this section back into those parameters which are finally desired as outputs. In a typical application, the method outlined in this study was used to vary a given design by systematically translating it into force, stroke, current, and voltage parameters. The prototype used pressure as the com-

Fig. 29—Tracer mechanism follows the cam path as the cam rotates to maintain pressure between air jet and receiving nozzle at cam periphery



mon denominator. Altogether 35 solutions were found where previously only four were available, including the pressure system. Although many of the 35 were impractical, sufficient number offered satisfactory or better solutions than the original.

Gives Answer to System Behavior

For those interested in the dynamic overall behavior of such a translator chain, the analysis or block diagram gives directly the answer of dynamic overall behavior of the system. By applying the rules of La Place transformation to parallel and in-series arrangements of individual elements whose La Place transform is known, all the possible solutions are obtained. If F_1, F_2, F_3 represent the La Place transforms of individual translators, we obtain by an in-series or chain arrangement an overall transform $F_s = F_1F_2F_3 \ldots$ and in case of a parallel circuit $F_s = F_1 + F_2 + F_3 \ldots$ while a feedback circuit with F_2 in the feedback furnishes $F_s = F_1/(1 + F_1F_2)$.

It is hoped that a systematic survey of translators and operators—giving specific data on their accuracy, price, characteristic, size, weight, serviceability, life expectancy, availability and La Place transform—will become available in the future. This appears to be a worthwhile project because it would enable the designer to explore systematically a great variety of possible solutions instead of limiting himself to the few obvious ones which are available or appear to be promising. Last, but not least, it will serve to clear the relentlessly growing wilderness of "new" patent ideas as many of the sparks of genius will show themselves as variations of a theme.

Suggestions of Prof. D. P. Campbell, Mr. Guido Wuensch, Mr. Paul Glass and Dr. M. E. Droz are gratefully acknowledged. The following photographs were furnished by:

Askania Regulator Co. ..... *Figs.* 10, 13, 18, 22, 29
General Precision Laboratory Inc. ..... *Figs.* 30, 31,
Librascope Inc. ..... *Figs.* 8, 12, 14, 27, 28

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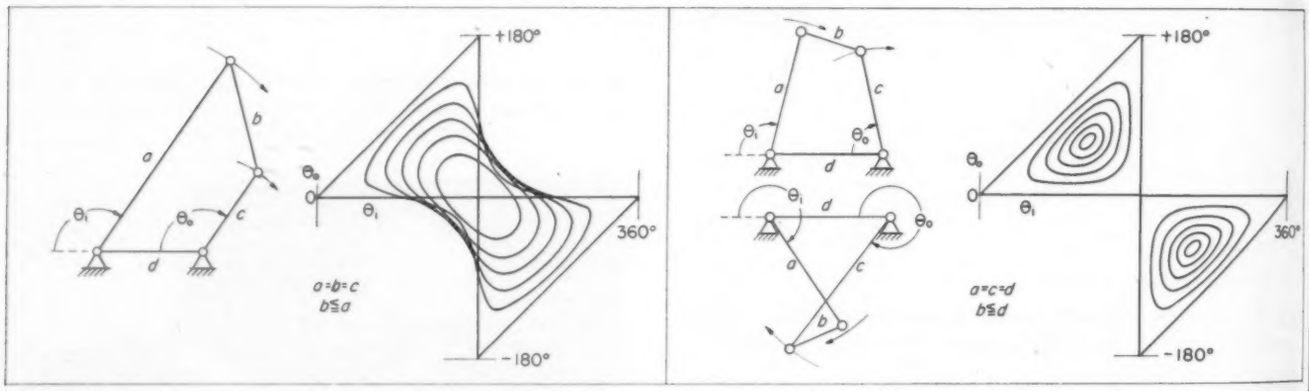


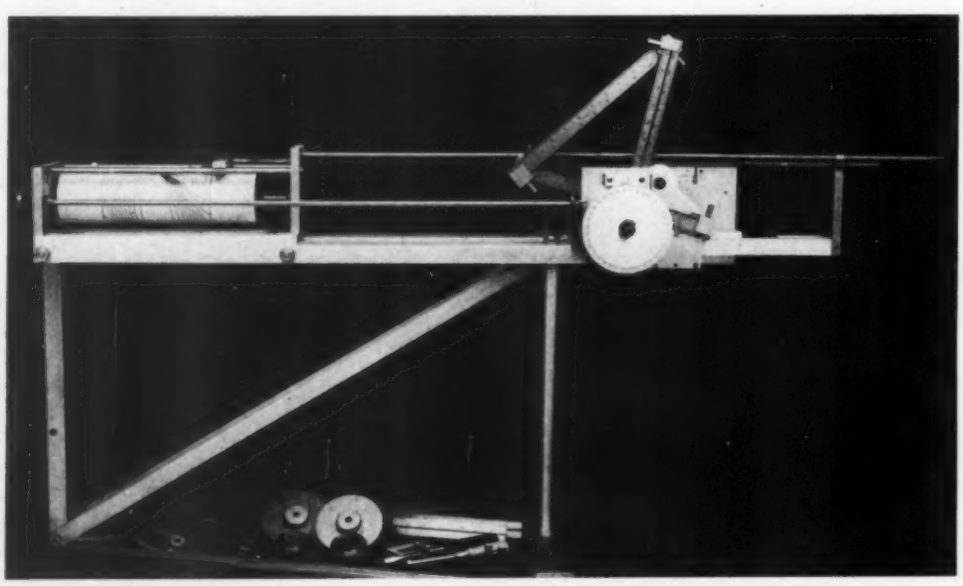
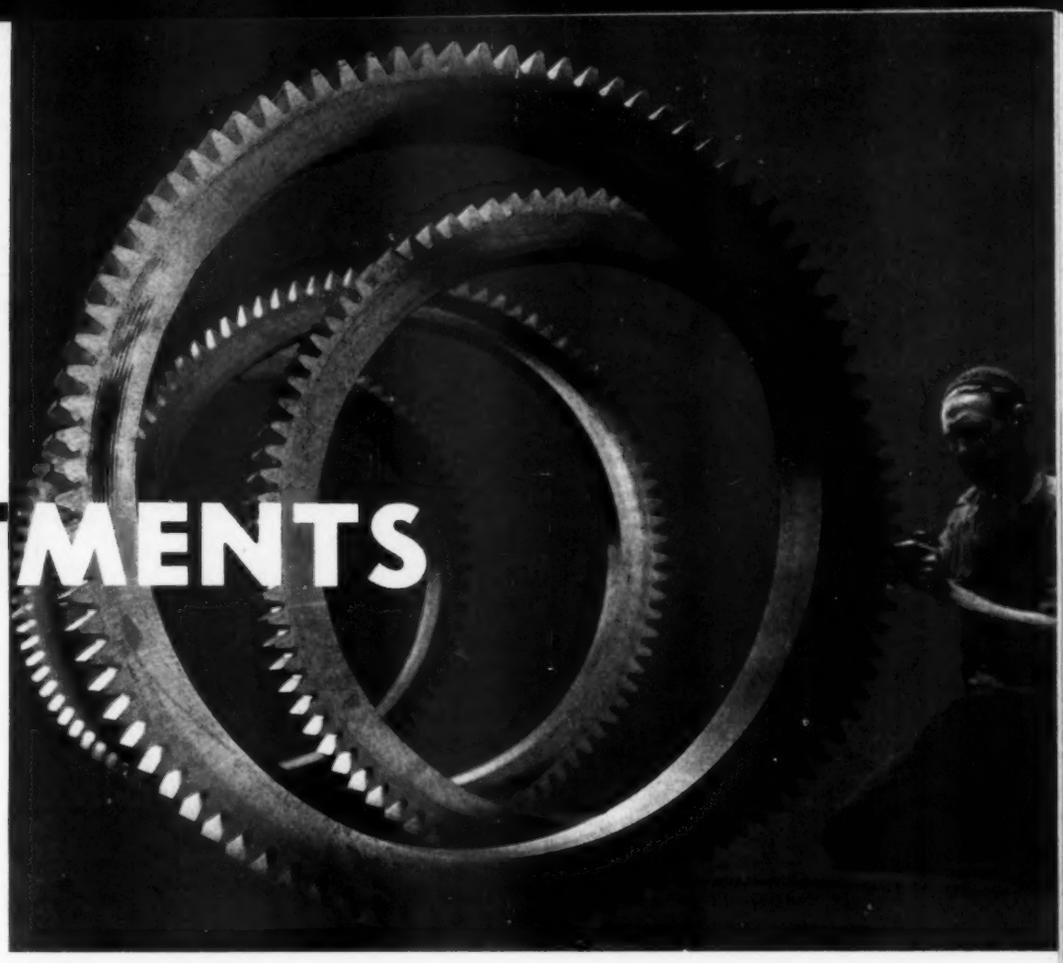


Fig. 30—Above—Typical paths traced by four-bar linkages for rotating connecting-rod and rocker type linkages

Fig. 31—Left—Device employing four-bar linkages will match any motion and determine maximum errors

HEAT TREATMENTS

. . . Their Selection and Specification in Design



By Norman N. Brown
Resident Manager
Cincinnati Branch
Wheelock, Lovejoy & Co. Inc.
Cambridge, Mass.

Part 3—Combination Hardness and Toughness

THIS series of three articles has been written primarily to aid the designer and engineer in selecting and specifying heat treatments that will result in the attainment of the desired physical properties in various machine parts. Part 1 covered a brief resume of types of steels and discussed treatments suitable for developing physical properties associated with toughness. Part 2 of the series discussed those associated with hardness and this final part will deal with heat treatments pertinent to the heat treating category of combination hardness and toughness.

Because combination hardness and toughness represents a compromise between hardness and toughness in most cases, there are almost endless variations in the specifications possible and only the most common and general situations which cover the majority of parts falling in this classification can be treated.

Normalizing: Generally this treatment is used in the interests of toughness and hardness in the processing of very large bars which do not respond well to the usual quench and draw methods described under Normalizing in the Toughness category, Part 1. It is, as mentioned before, always desirable to normalize forgings prior to subsequent treatments.

CASE HARDENING: Low-carbon alloy steels are generally used on jobs which require a very hard wear surface and some degree of toughness. It has been customary to state, in such instances, that the use of alloy steel results in a hard case backed by a tough core to resist shock loads. However, some questions have been raised that cast some doubt as to this statement, on the theory that any impact strong enough to tax the physical properties of the core would have cracked or shattered the case long before reaching the core.

If this new line of thinking holds true, it would seem as if the physical properties of the core have other functions. One of these is that the core must be hard enough to back up the case and thus resist crushing of the case by heavy pressure. The car-

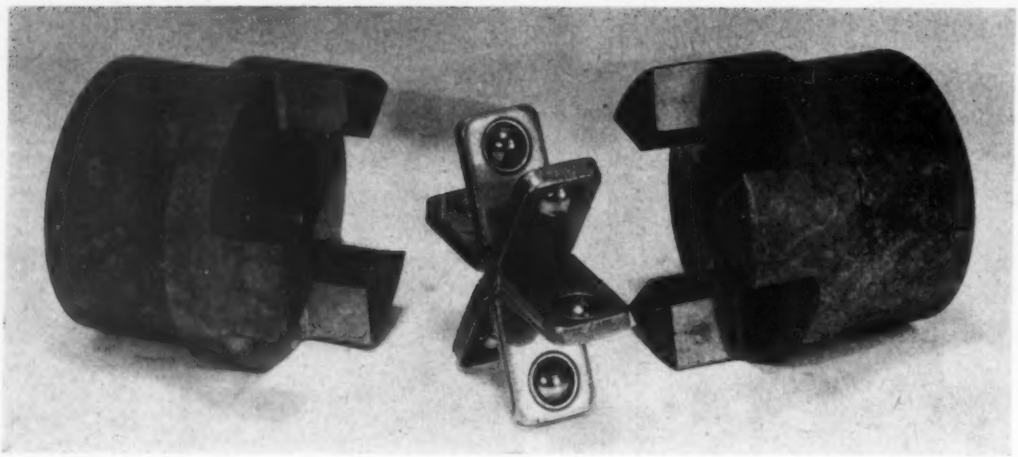


Fig. 10—Left — Flexible shaft coupling of ball-bearing design made from a carburized low-carbon alloy steel

burized AISI A-4620 type pinion gears shown in *Fig.* 6 illustrate this point. Another use for a tough core is on parts which are selective case hardened where those portions not hardened must have strength.

Straightening after case hardening is another instance which requires good core properties especially on parts of slender design such as shafts, slides, etc., that are likely to distort considerably during treatment. The importance of this factor was brought out clearly in the case of some long tool bodies. Originally a steel of AISI C-1117 type was used; the parts were finish machined, pack carburized and hardened to produce a case about 0.065-inch deep, given a short, low draw of 250 F for fifteen minutes to relieve strains, straightened, and ground. In service the bodies were satisfactory, but the difficulty was that too many pieces cracked in the straightening operation before they could be put into service. Investigation revealed that although the case had enough strength to resist the straightening stresses, the core did not in those parts that broke. AISI A-4615 was then used, being given the same heat treatment. The better response of A-4615 to the treatment resulted in a substantial reduction in the number of cracked parts.

As under the Hardness category, it is difficult to state in so many words how thick a case should be, as service conditions vary widely. Usually the case thickness should not be more than one-sixth of the section thickness if toughness is to be maintained. The flexible ball-bearing coupling in *Fig.* 10 is an interesting part fitting into this discussion. It was machined from a low-carbon alloy steel, carburized and hardened to develop a case 0.060 to 0.070-inch deep with a hardness of 62 to 65 Rockwell C.

Hardening of Thin Sections

Parts, such as spray nozzles of various kinds, with thin cross sections require extreme care to prevent case hardening all the way through. Such sections become too brittle for practical use. Liquid salt baths, which in general permit close control of case thickness—more so than pack or gas carburizing—can be used to good advantage on these jobs. There are many good salts on the market that can be considered including DuPont, A. F. Holden, E. F. Houghton (Perliton), and Chapmanizing salts. Developments in salt-bath treatments in recent years have made possible cases approaching the depth and toughness of those produced by pack or gas methods. In general, however, a case developed by salt bath is thinner and more brittle.

One of the advantages of case hardening is that it increases fatigue resistance. Fatigue failures are tensile failures and the case hardening introduces surface compressive stresses which counteract applied tensile stresses. For this reason, as well as to obtain better wearing qualities, some crankshafts, such as that in *Fig.* 11 which was made from a special 4616 steel, camshafts and other similar parts are often carburized.

Standardize Specifications

The specifying of case-hardening treatments can be set up in a manner similar to that suggested under the Hardness category, keeping in mind possible distortion as well as the service conditions to which the case itself will be subject, which may or may not rule out a brittle case.

There are occasions when a part requires the core characteristics of a heat-treated medium-carbon alloy steel and, at the same time, must be very hard to resist sliding wear and to a small extent pressure as contrasted to a case that has to be heavy and resist shock applications. In such instances—medium-duty gears of certain types, toggle pins, etc.—a medium-carbon alloy steel (0.30 to 0.40 per cent and sometimes up to 0.50 per cent carbon) is used with a cyanided case. Usually the depth of the case is quite thin being 0.005 to 0.015-inch deep, but sometimes it is possible to obtain a depth of 0.035-inch. Parts, however, must be so designed that little distortion occurs in treatment because of the thin case which will not permit much grinding. Selective case hardening as on bearing surfaces may be employed also.

The chart in *Fig.* 12 shows in a general way the relationship of case thickness to overall service conditions on parts requiring a tough core and a hard, wear-resistant surface.

Nitriding (particularly selective): This treatment is good if an exceptionally hard surface combined

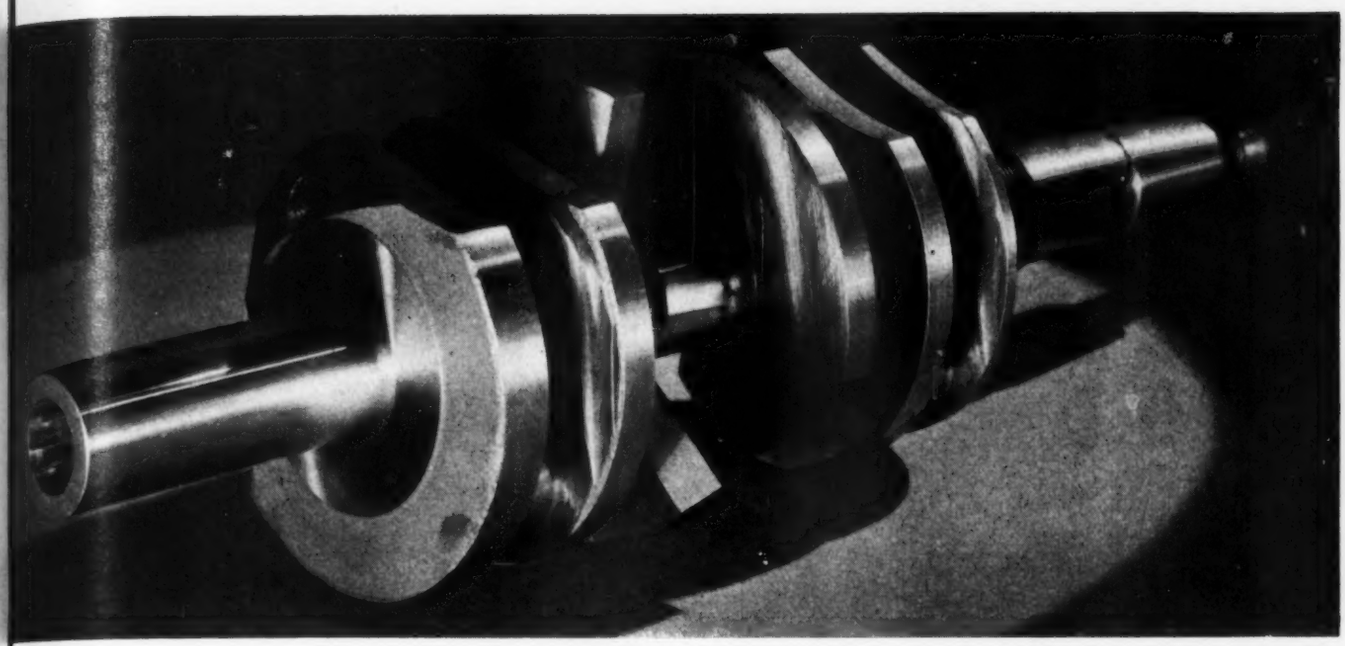
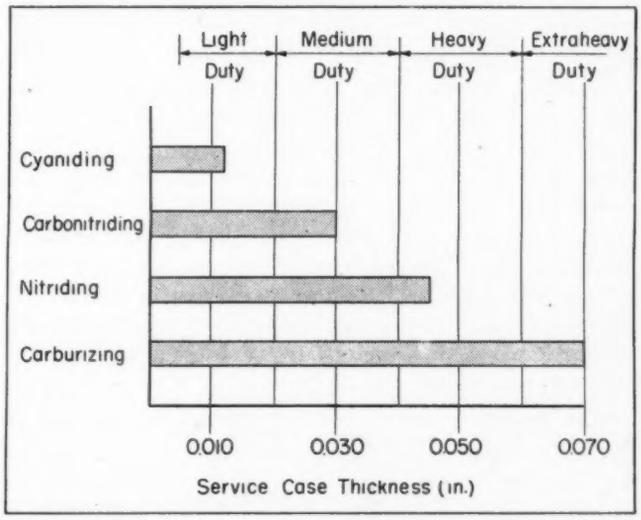


Fig. 11—Above—Engine crankshaft made from a special AISI 4615 type steel case hardened by carburizing

Fig. 12—Below—Chart showing relationship of case thickness to overall service conditions of hard-tough parts. Amount of distortion anticipated and amount of grinding must be added to obtain total depth of case needed. Gas carburizing will actually permit case thicknesses of 0.300 to 0.400-inch if desired. Medium-carbon alloys are generally cyanided and do not exceed 0.012-inch case. Low-carbon alloy steels are suitable for the full range



with tough body qualities is required. As was brought out before, special nitriding steels marketed under the name Nitralloy are most commonly used, but many medium-carbon alloys can also be effectively nitrided. Use of the latter grades results in a somewhat tougher case not quite as hard as that produced with Nitralloy. Since the average nitrided case is brittle and thin its use should be restricted to parts where that condition will not be a disadvantage.

When a part is to be nitrided, the surface should be clean and free of any decarburization. The steps in processing prior to nitriding follow the general pattern of those discussed under the Toughness category. If much machine work is to be done on preheat-treated material, it is usually stress relieved just prior to finish machining. This eliminates machining strains that might cause distortion in the subsequent nitriding operation. Because no quenching is involved in nitriding, distortion is usually negligible, except in the instance just mentioned where unrelieved machining strains cause difficulty. Nitriding is usually carried on between 900 and 1200 F so in the heat treatment of the steel before nitriding the drawing temperature will of necessity have to be about 1200 F or higher. Occasionally this point is overlooked by the designer and hardness or physical properties requiring a lower draw are specified which, of course, would be changed in the final higher heat of nitriding. Gears, pump shafts, liners, crankshafts, and rolls are among parts that are nitrided.

SURFACE HARDENING: The mechanics, precautions and other information concerning flame and induction hardening described in the Hardness category apply under these circumstances. When toughness is to be considered, the physical properties of the part will determine what steel and treatment to use prior to surface hardening and the procedures and suggestions under the Toughness category can be followed. In the interests of toughness, usually one of the steels in Groups III and IV, *Fig.* 1, (C-1045, A-4640, A-4142, etc.) heat treated to the proper physical properties is used.

Steels with 0.40 to 0.45 per cent carbon content have been the ones most commonly used for flame and induction hardening but improvements in technique, equipment and quenching solutions have made it possible to use steels with up to 0.50 per cent carbon without taking particular precautions during treatment. An example of this is the use of a special 0.50 per cent carbon high manganese-chromium-molybdenum alloy steel for heavy duty gears, pinions, etc. In addition to being an exceptionally good ma-

chining steel it has deeper hardening qualities (due in part to the 0.50 per cent carbon) than the 0.40 per cent carbon grades. This is an advantage on deep-cut parts machined from preheat treated stock in which the physical properties of the deep-cut sections have to be close to those of the shallow-cut sections.

Response of this steel to flame hardening is shown in *Fig.* 13. The material (4⅛-inch round) was machined to the irregular shape shown and then cut in half making two pieces 2½ inches long. The darkened surfaces were flame hardened and quenched, etched on the surface and midsection to show the heat-affected zones. A hardness survey on the hardened faces show the affected zones with Rockwell C hardnesses as given in *Fig.* 13.

Low Distortion Hardening

Normally, the distortion on flame or induction hardened pieces is very slight, but there is apt to be considerable distortion if only one surface of comparatively long parts, such as slides, is hardened. In such cases distortion can be minimized by also surface hardening the other side. The moral here is that parts should be surface hardened as symetrically as possible. If a part is very fussy and has close tolerances, a steel with air hardening properties (as far as flame or induction hardening is concerned), *Fig.* 13, can be used advantageously. Distortion, if any, would be less than if an oil or aqueous quenching solution were used as a quench. Crankshafts, gears, pinions, rolls, spindles, and worms are among parts that can be surface hardened. *Fig.* 14 shows a miscellaneous group of parts that have been induction hardened.

THROUGH-HARDENING: The possibilities for the use of this treatment, which, as mentioned before, basically involves heating, quenching and drawing, are wide and varied. For this reason and also for its comparative simplicity it is one of the most popular and extensively used methods of obtaining hardness and toughness. It is probably safe to say that most of the parts thus treated are not as ideally hard or tough as would be desired, but hard and tough enough for practical and economic processing and service.

Medium-carbon alloy steels in Groups IV and V, *Fig.* 1 (A-4140, A-4340, etc.) are used at hardnesses from about 32 to 50 Rockwell C for the majority of jobs in this category. From 50 to over 60 Rockwell C, special tough oil and water-hardening higher carbon steels are used. These are grades such as AISI A-9262 and others usually marketed under tradenames by reputable steel companies. Basic facts to keep in mind are that as the hardness increases the tensile and yield strength increases which is beneficial to some parts subject to straight pulling stresses and very little bending or other "side" forces. As hardness increases, the elongation, reduction of area, and impact strength decreases, which is detrimental to most parts such as shafts, gears, pinions, studs, clutch dogs, etc., in this Hardness-Toughness category.

Before going over the various possible heat treating specifications a short review of the factors involved in determining whether to use a medium-alloy in Group IV, *Fig.* 1, or a rich alloy in Group V might be worthwhile.

Medium Alloys (AISI A-3140, 4140, etc.): Steels in this group are best adapted and most widely used for heavy-duty shafts, gears, axles and studs which must withstand heavy loads, wear, shock, bending, and the like. Generally speaking, these steels are used on parts at hardnesses under 50 Rockwell C.

Response to Heat Treatments

Rich Alloys (AISI A-4340, 2345, etc.): Response to heat treatment by oil quenching, especially in massive sections, and splendid resistance to shock in the heat-treated condition characterize the steels in this group. These steels are used for much the same parts as those in the medium-alloy group, but where greatest possible strength is required. In the lower hardness ranges (under 321 Brinell) in smaller sections (under 3½-inch) there is no marked difference in physicals between this and the medium-alloy group. In the higher hardness ranges and larger sections when heat treated this group shows up to best advantage. (Cost is also greater than for medium-carbon alloys.)

As brought out in discussing through-hardening in

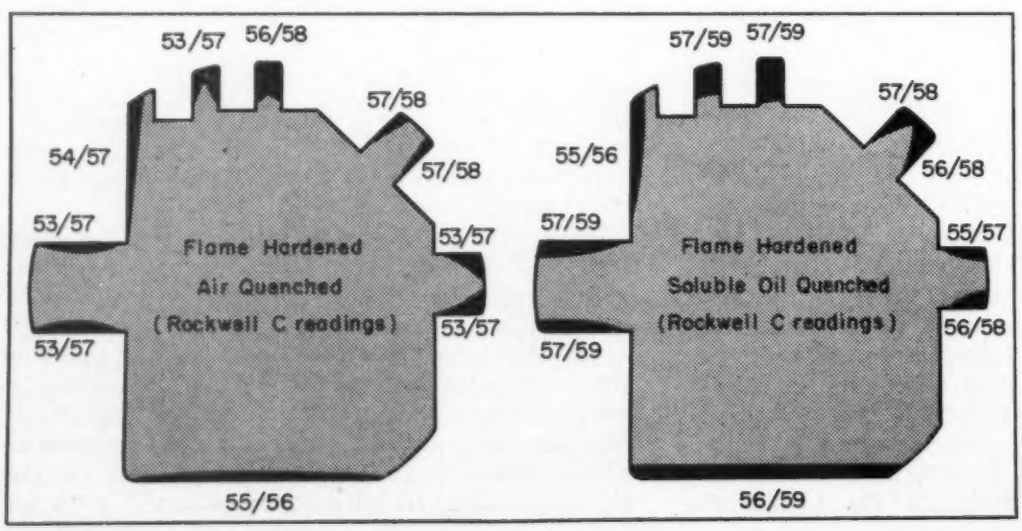


Fig. 13—Hardness readings on various projection designs showing response of a special 0.050-carbon high-manganese - chromium-molybdenum alloy, flame hardened, using air and soluble oil quench

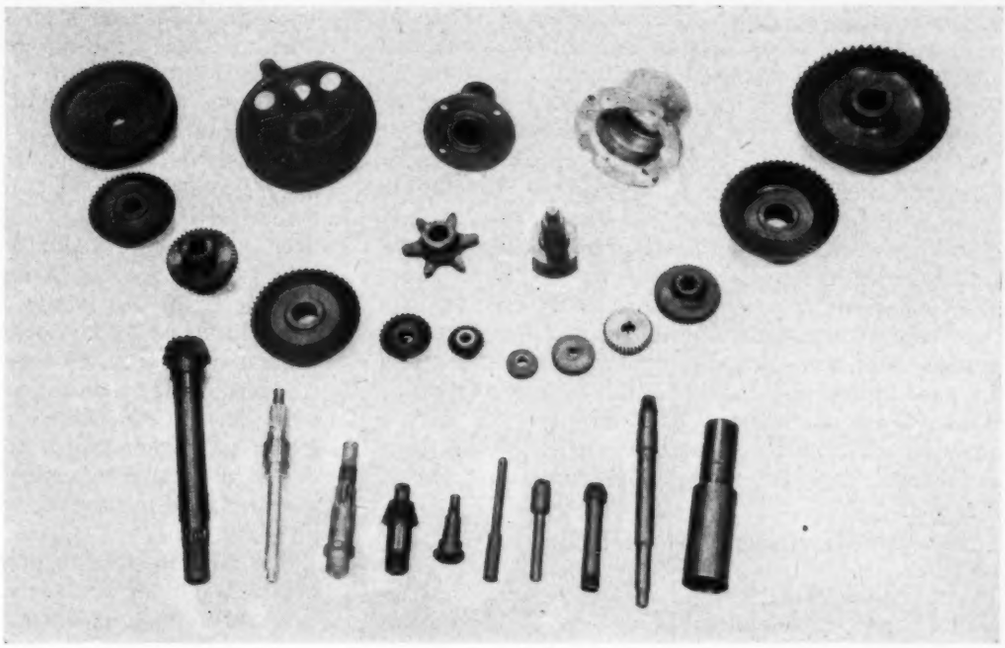


Fig. 14—Right — Group of miscellaneous gears, shafts and pinions hardened by the induction method

Photo, courtesy General Electric

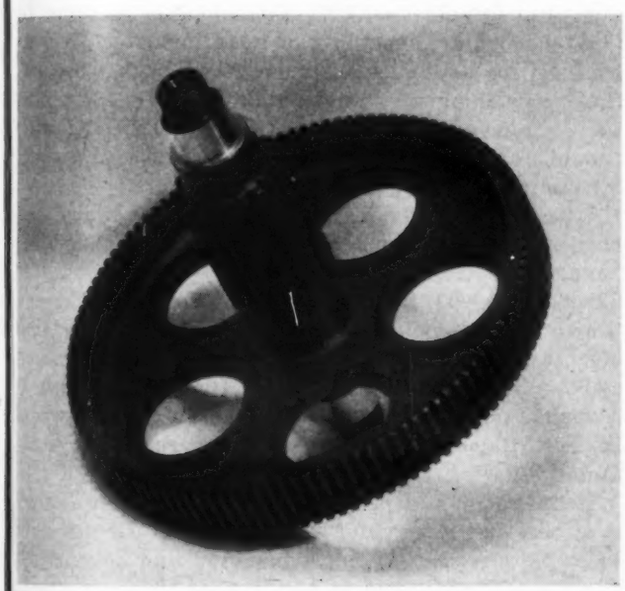


Fig. 15—Gear machined from a medium-carbon alloy steel forging and heat treated to 48 to 50 Rockwell C

the Toughness category, the medium-carbon steels vary in machinability in the heat-treated condition. Hardness of 32 or 33 Rockwell C is about the limit at which most of the standard grades are being rough machined economically at the present time although some of them, at some sacrifice in cost, can be machined at hardnesses up to about 36 Rockwell C. There are some tradename steels on the market with similar physical properties that machine considerably better than the standard grades in the 32 to 38 Rockwell C hardness range. Plant facilities, price, processability, and other factors are accorded varying degrees of importance in different companies, resulting in different heat-treating procedures to achieve the same end result. The most practical approach, therefore, will be to suggest heat-treating specifications which can be used effectively, keeping in mind the pertinent factors concerning types of steels and machinability. These specifications are:

Parts machined from preheat-treated steel (32 *to* 38 *Rockwell C*)

Comparatively symmetrical or chunky design
- Heat treat
- Machine

Compartively long or intricate design
- Heat treat
- Stress relieve (to relieve straightening strains)
- Machine

Parts heat treated after machining (32 *to* 50 *Rockwell C*)

Comparatively symmetrical or chunky design
- Anneal
- Machine
- Heat treat
- Grind

or
- Anneal
- Rough machine
- Heat treat
- Finish machine
- Grind

Parts of comparatively long or intricate design
- Anneal
- Rough machine
- Heat treat
- Finish machine
- Grind

or
- Anneal
- Rough and finish machine
- Stress relieve
- Heat treat
- Grind

or
- Anneal
- Rough and finish machine
- Martemper (fully effective in sections up to about 3 inches)
- Grind (can stress relieve before Martempering if desired)

The gear in *Fig.* 15 was made from a medium-car-

bon alloy-steel forging. After normalizing and annealing, the steel was rough and finish machined, heat treated (oil quenched and drawn) to 48 to 50 Rockwell C, and used as shown without grinding or cleaning.

Many parts such as clutch units, liners, bushings, rolls, cams, and locating pins requiring hardnesses from 50 to over 60 Rockwell C are made from the high-carbon (0.60 to 1.10 per cent carbon) oil and water-hardening steels because deeper high hardness and strength is wanted for wear or other reasons than can be obtained with the use of lower carbon grades. Also, some of the tougher oil-hardening steels are used in lieu of carburized steels to take advantage of the lower distortion in treating as well as the adequate strength and wearing qualities. Chuck jaws and clutch dogs are examples of such applications.

Tempering Requirements

Attention should be given to the drawing or tempering time if toughness is of special importance when a high-carbon steel is used. An hour to an hour and a half per inch of cross section is the usual length of time necessary at drawing heat to obtain proper hardness. If that drawing time is extended to two or three hours per inch the toughness will be substantially increased with little change in hardness. The designer should definitely specify the longer draw if he thinks it necessary because, unless he does, the heat treater will usually only draw the normal length of time.

Shallow-hardening water-quenching steels are used on jobs requiring a very hard (62 to 68 Rockwell C) case from ⅛-inch to ⅜-inch deep backed by a hard, touch core. The jeweler's lathe spindle assembly in *Fig.* 16 was made from such a steel. The parts were machined from annealed bar stock, heat treated to about 64 Rockell C and ground.

The heat treating specification for these high carbon steels is generally set up as follows:

Anneal (bar stock is usually furnished in the annealed condition)
Rough and finish machine
Stress relieve
Heat treat
Grind

If conditions are favorable, parts made from the high-carbon oil-quenching steels can be Martempered, Austempered or Isothermally treated as described under Through-Hardening in the toughness category.

In concluding the discussion of combination hardness and toughness, the following example clearly illustrates the number of factors that have to be taken into consideration in selecting a steel and treatment and why specifications should be as flexible as possible, or at least thoroughly investigated before setting them down on paper. The part in question was a gage, about 6 inches long, threaded for about 2½ inches and ⅞-inch hexagon for the balance of the length. For gaging purposes, the hexagon portion had to be over 60 Rockwell C hardness.

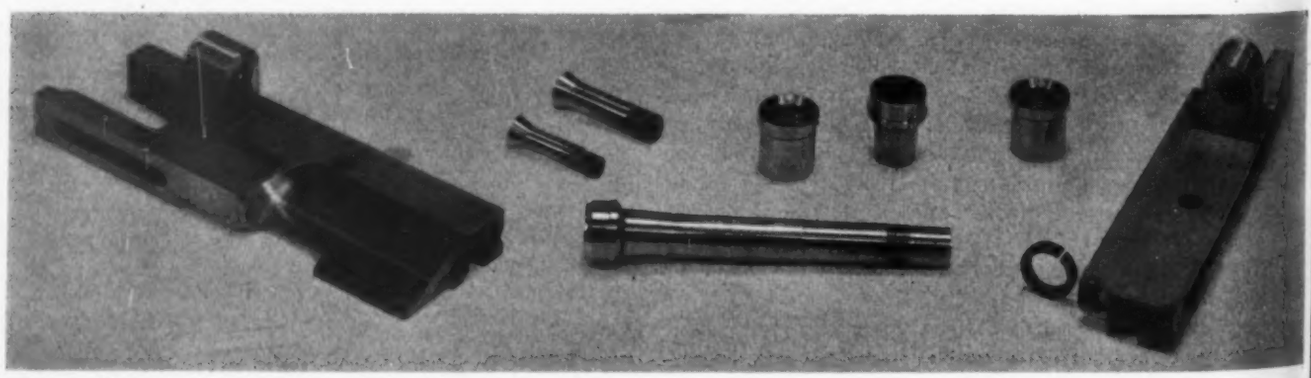
First made from cold-drawn C-1020 hexagon stock, the piece was carburized and hardened all over to 63 Rockwell C. Because of service stresses the threads chipped on some gages and others broke across the threaded section. Furthermore, considerable distortion occurred in treating which necessitated excessive grinding.

The first thought to improve the part was to use a low-carbon alloy and case harden the hexagon section only. This idea was discarded when hexagon, low-carbon alloy steel was unavailable. Next, a medium-carbon alloy which could be obtained in hexagon sizes was considered with the thought in mind of flame hardening, cyaniding or nitriding after preheat-treating for toughness. This was discarded because flame hardening would not develop a sufficiently hard surface, cyaniding would not produce a case deep enough, and nitriding was too expensive and time-consuming a treatment.

Finally made from a tough 0.75 per cent carbon oil-hardening steel, round bar stock was used and the hexagon section machined. The gage section was hardened to 62 Rockwell C and the threaded end drawn back to about 45 Rockwell C. The oil-hardening steel was selected instead of a low-carbon alloy, which could also have been machined from round stock in a similar manner, because distortion in treating would be less. Reports indicate the gages are giving satisfactory service.

Ramifications of heat treating processes and specifications are many and varied. Those discussed in these articles are the most common and cover most general situations. It is hoped that presentation in this manner will provide the design-engineer with a clearer insight into this complicated subject which will help eliminate improper heat treating which can lessen and even nullify the effectiveness of expensive and otherwise carefully designed machine parts.

Fig. 16—Jeweler's lathe components made from a shallow-hardening type special 0.95-carbon water-hardening steel



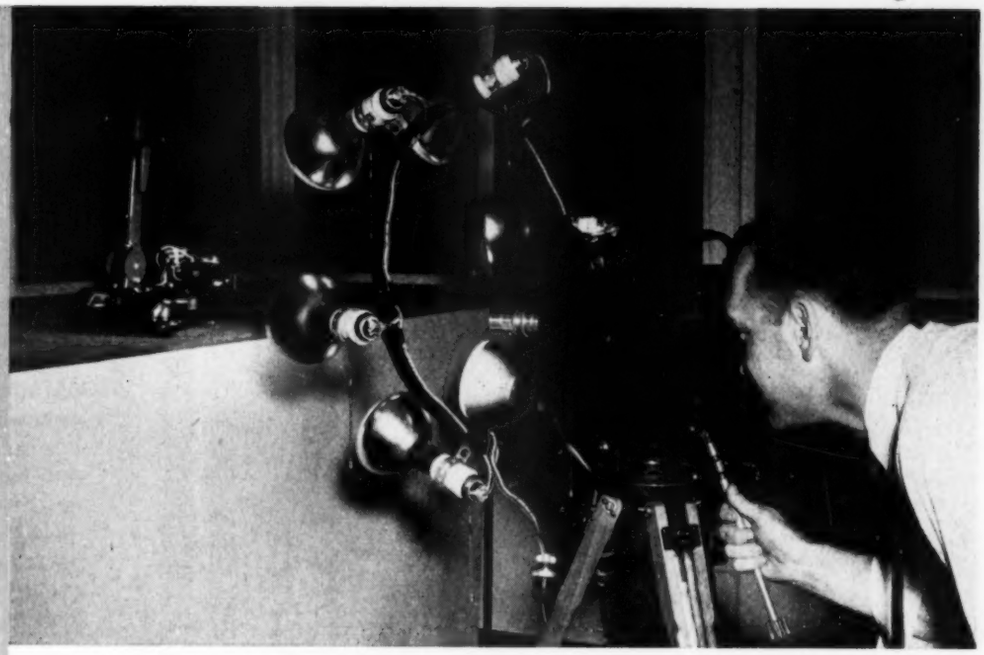


Fig. 1—Setup for a high-speed motion picture study of a vacuum cleaner

High-Speed Motion Pictures

. . . detect defects in design

By
L. G. Waller
Research Engineering
Eureka Williams Corp.
Bloomington, Ill.

ALTHOUGH high-speed motion pictures are generally regarded as an aid to proportioning of machine parts they also can serve as a guide to the selection of materials. For example, if excessive wear is suspected, theoretical calculations frequently cannot offer a concrete answer as to whether the wear results from wrong proportions or from a failure of materials to perform as predicted.

In solving such problems, motion pictures of 1000 frames or more per second help the designer to observe what actually occurs during operations and to assign the fault where it belongs. These motion pictures, projected at the standard silent speed of 16 frames per second, effectively "magnify" time by factors of from 65 to 200. In other words, a cycle actually taking place in 1/100-second may appear on the screen for as long as two seconds.

To show the effectiveness of motion pictures in design analysis, this article outlines two actual cases in the experience of the Eureka Williams Corp., manufacturer of vacuum cleaners and oil-fired heaters.

VACUUM CLEANER BELT: In attempting to increase the life of the drive belts used in its upright cleaner models, Eureka was confronted with the question of whether the belt at normal speeds had sufficient clearance to vibrate without rubbing the base or the top of the cleaner casting. Since the brush roll driven by the belt rotates at 3500 rpm, suspected abrading action could not be observed with the unaided eye.

To permit photographing the belt at a speed of 3000 frames per second, a part of the casting was cut away. A Kodak high-speed camera surrounded by six photo spot lights was used to take the motion pictures of the belt's travel between the drive shaft and the brush roll, *Fig.* 1. Separate exposures were made of a belt when new and after equivalents of three, six and nine month's wear.

As evidenced in *Fig.* 2 (consecutive frames enlarged from the film) vibration was not excessive and no abrading action occurred with a new belt. Similar evidence was apparent from films of the belt made after equivalents of three months' and six months' wear. However, after a 9 to 12-months' equivalent, the belt was stretched to the point where its vibration brought it in contact with the base of the casting, *Fig.* 3. These frames are consecutive and it

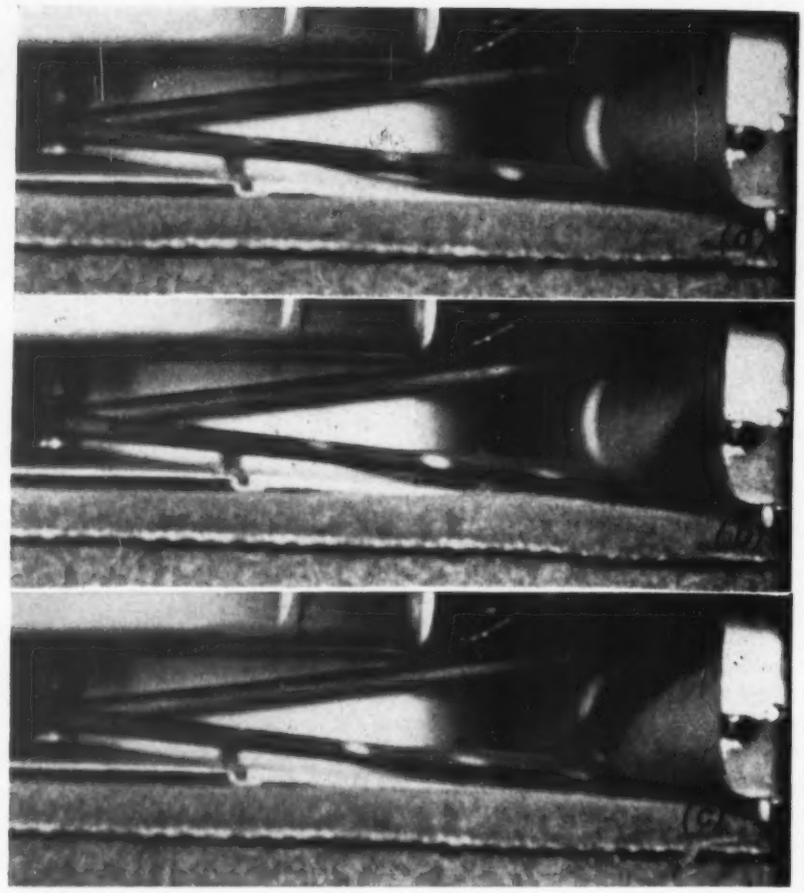


Fig. 2—Above—Consecutive frames (1/3000-second per frame) of a film of a new vacuum cleaner belt in operation. Vibration was not excessive; no abrading action was evident

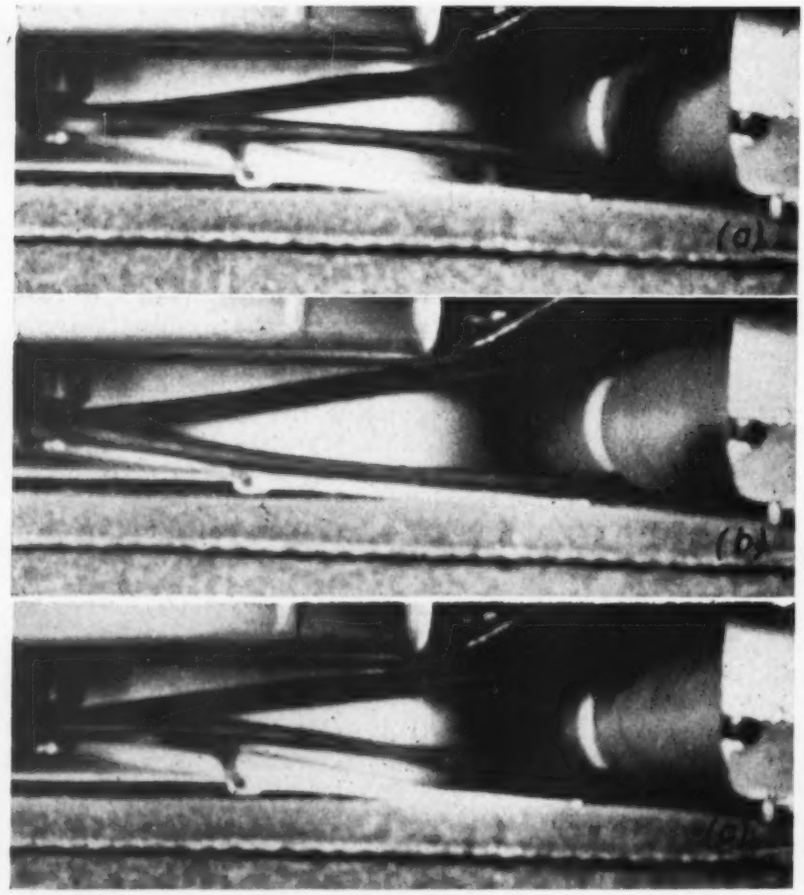


Fig. 3—Left—Same belt as in Fig. 2 after the equivalent of nine to twelve months' use. Belt was sufficiently stretched to bring it into contact with the base of the casting

was apparent that the belt was slapping against the casting at a considerable frequency. Because of the abrading action which resulted, the rate of wear increased rapidly during the final stages of the belt life. This caused slippage of the brush roll and a resultant decrease of efficiency of the cleaner.

Perhaps the most surprising information derived from a study of the motion pictures was that the vibration was greater on the drive, or tension, side of the belt. From a practical standpoint, however, Eureka engineers were more interested in the fact that clearance was wholly adequate until such a time as the belt became distorted from normal use. In view of this, tests were conducted to find a new type of belt material which would successfully resist distortion, prolonging the period of abrasion-free action. Several dozen compounds were tested before a final selection was made. The result is an increase in normal belt life of more than 100 per cent.

Incidentally, during the course of these motion-picture studies, Eureka's engineers noted that the amplitude of vibration of the rug offered a means of effectively measuring the "beater action" of the cleaner. While this action is not apparent in the enlargements as shown, it is quite visible when the pictures are projected on a screen. The engineers were able not only to measure the effects of slippage caused by belt wear, but also to determine the effect of bristles of different lengths and diameters. An analysis led to the adoption of three rows of bristles spirally mounted on the brush roll, each row differing in length, diameter, and stiffness.

ROTARY AIR PUMP: A second example of the influence of high-speed movies on the selection of materials is provided by the study of a rotary air pump used in low-pressure oil burner units, *Fig.* 4.

As the rotor turns on its shaft, fiber vanes in each of six slots are driven by centrifugal force to sweep the walls of the pump housing.

Seeking to eliminate vibration from this unit, engineers who photographed the rotor expected to charge the fault to one of three possibilities: shaft whip, action of the vanes in their slots during rotation, or compression of the oil film inside the pump either at the point where the rotor is tangent to its housing or at the root of the vanes.

Despite difficulty in adequately lighting the rotor for exposures of less than 1/15,000-second, the motion pictures revealed that none of these theories were correct. Using a microfilm reader on which the 16-mm films were projected and measured a frame at a time, project engineers found no appreciable shaft whip. The fiber vanes were seen sliding freely in their slots without deflection while rotating. Only slight evidence of oil compression was found at the root of the vanes.

When these mechanical possibilities of vibration were eliminated, attention was turned to the materials used for the rotor and shaft. It was found by measurement of enlarged frames that the high ductility of the aluminum rotor resulted in the opening of the bore under the stresses of high-speed operation. A change in specifications was issued to replace the aluminum rotor with one of cast iron; this resulted in eliminating the vibration. In the examples cited, high-speed motion pictures led, primarily, to a change in materials. Quite possibly, the information obtained might have been secured by other methods, with comparable end results. However, the use of high-speed motion pictures undoubtedly eliminated time-consuming, trial-and-error experimentation.

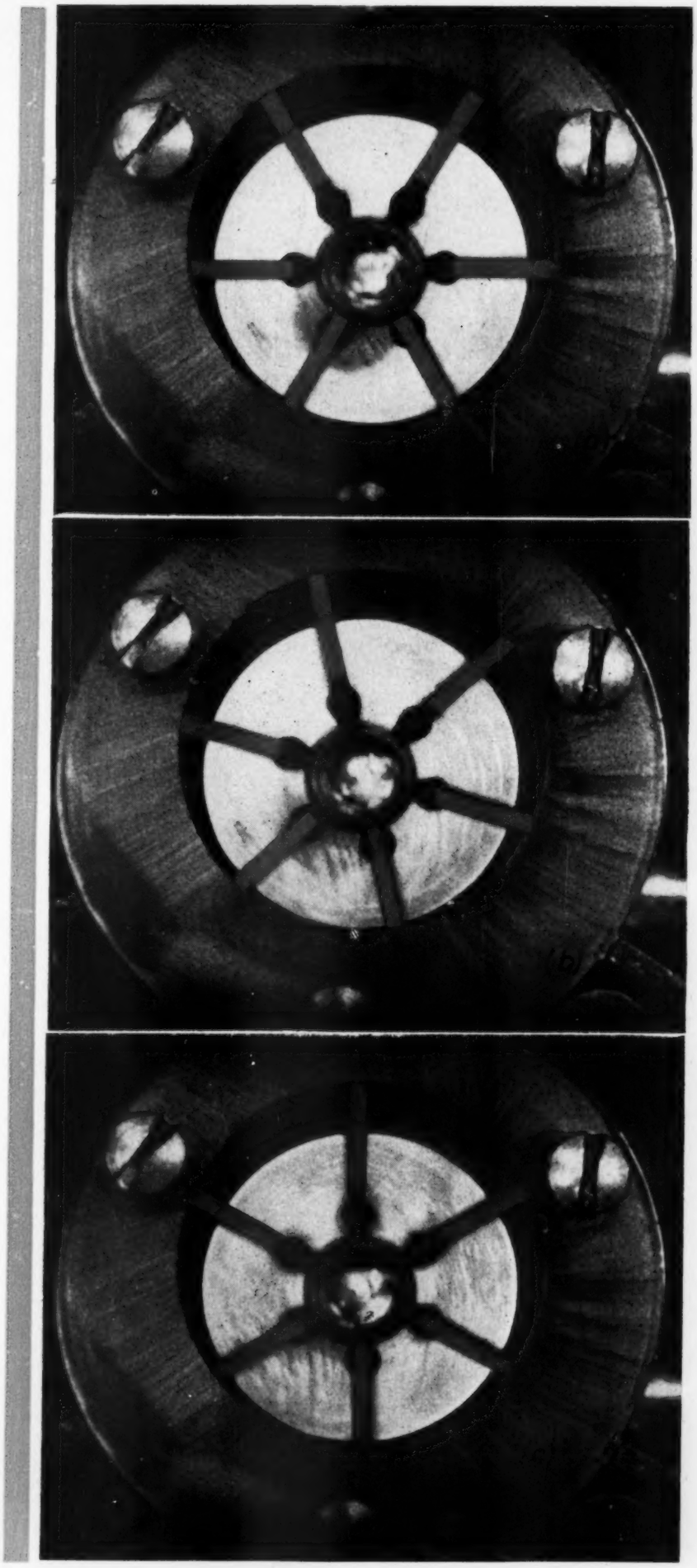


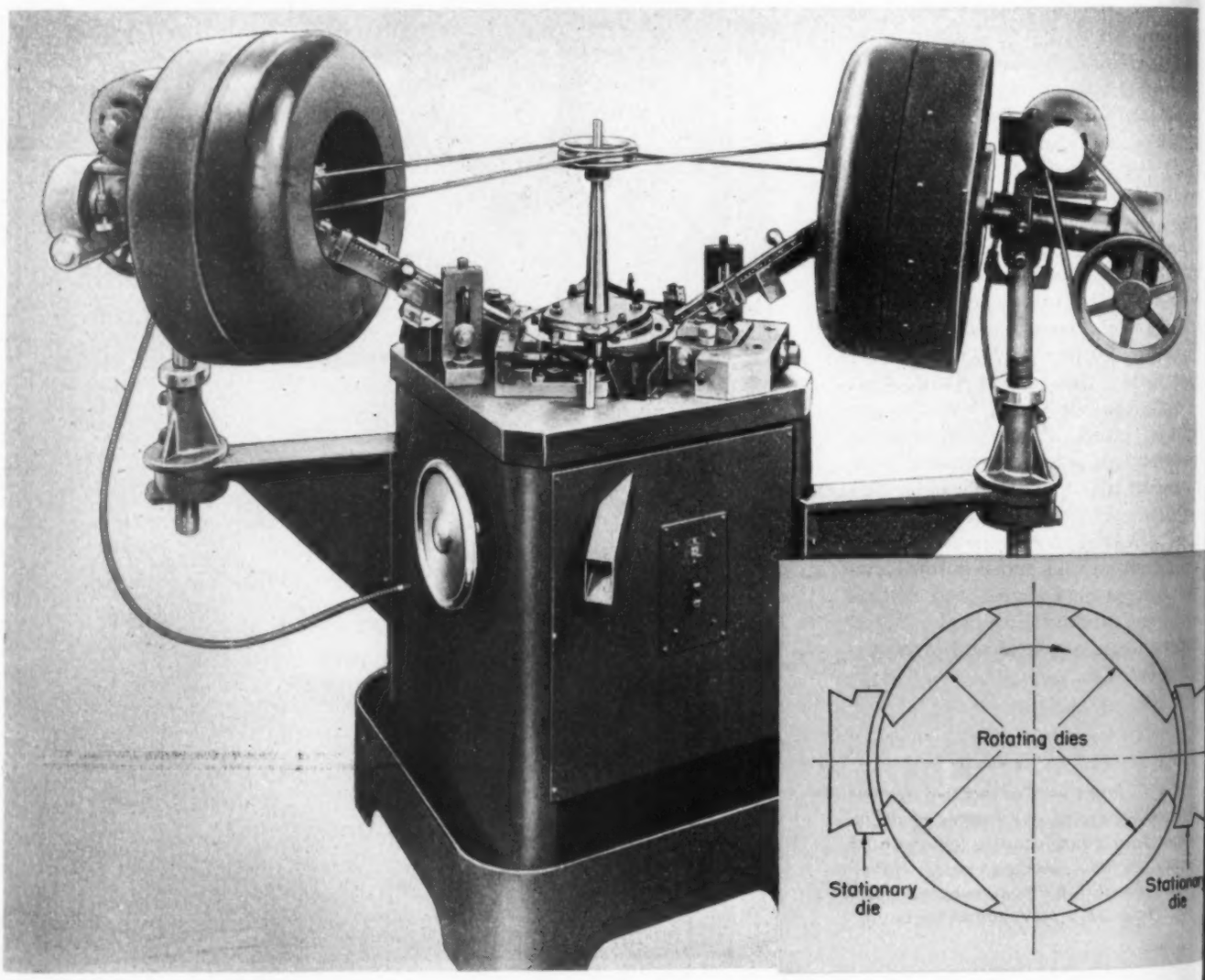
Fig. 4 — Right — Consecutive frames (1/15,000-second per frame) of a film of a rotary pump used in low-pressure burner units. Measurements taken from enlarged frames revealed rotor distortion as major vibration cause

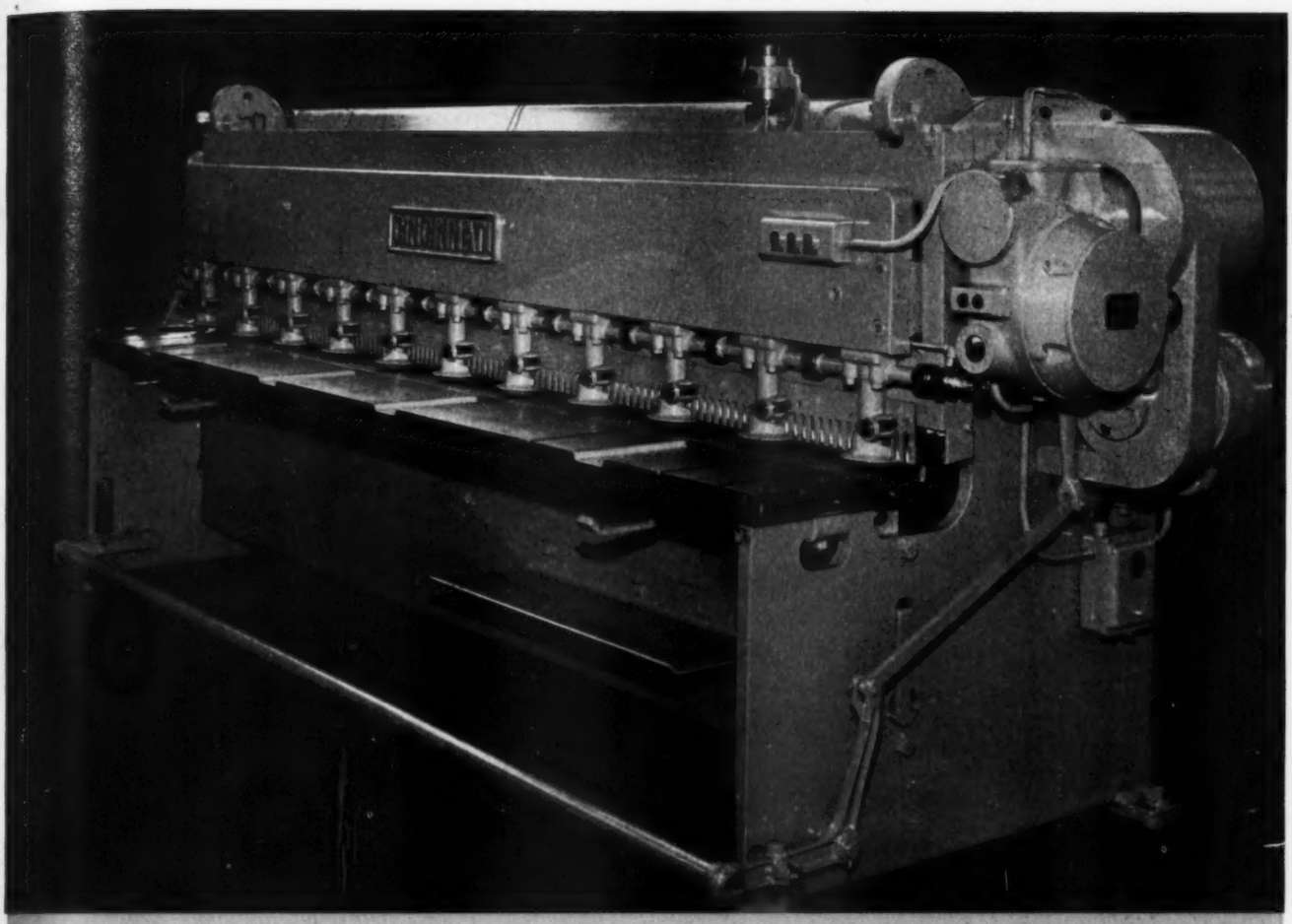
Contemporary DESIGN

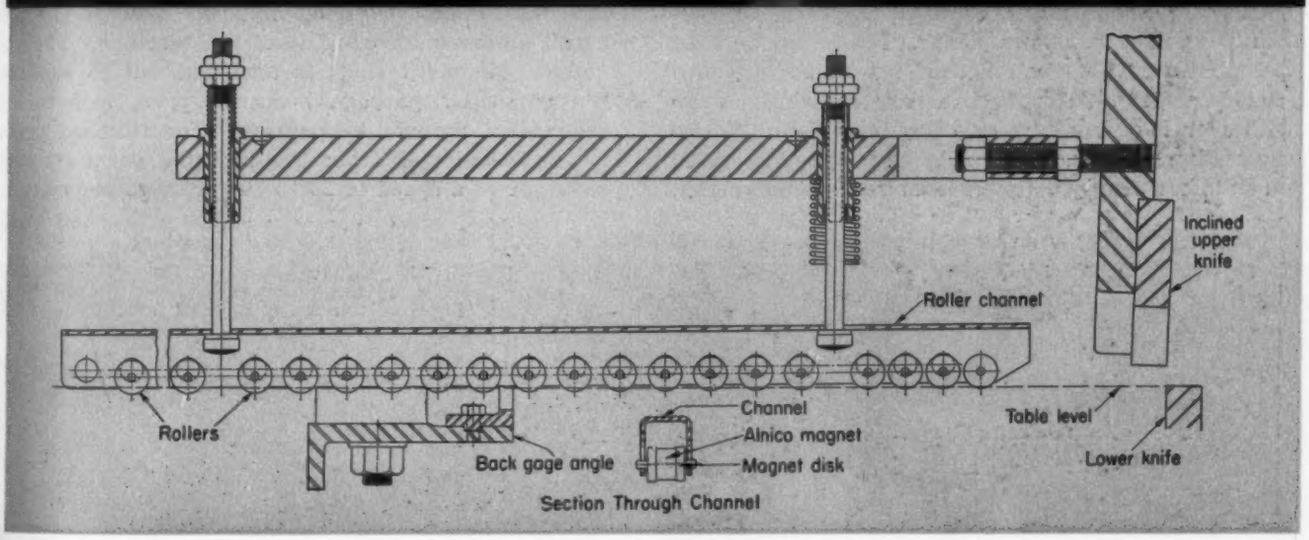
Thread Roller Employs Planetary Action

PLANETARY action between four rotating and two stationary dies in the D. H. Prutton Machinery & Tool Co.'s No. 120 thread-rolling machine, below, permits rolling up to 25,000 threaded pieces per hour. When rolling concentric, parallel grooves, the machine can produce 36,000 parts per hour. Each of the four moving dies, shown in the sketch, inset, below, threads one bolt against each stationary die per revolution, resulting in eight rolled pieces per cycle. The machine is designed to provide complete adjustability of the feeding mechanism with all adjustments accessible to the operator.

Parts are fed down inclined chutes from individually-driven rotating hoppers. A rejector wheel in each hopper, belt driven from a spindle on the rotating die, throws off any parts that are not properly aligned to enter the die. Feeding fingers, triggered by an adjustable cam mounted on the rotating die assembly, pick parts from the feed chutes for insertion between the dies at the proper instant.

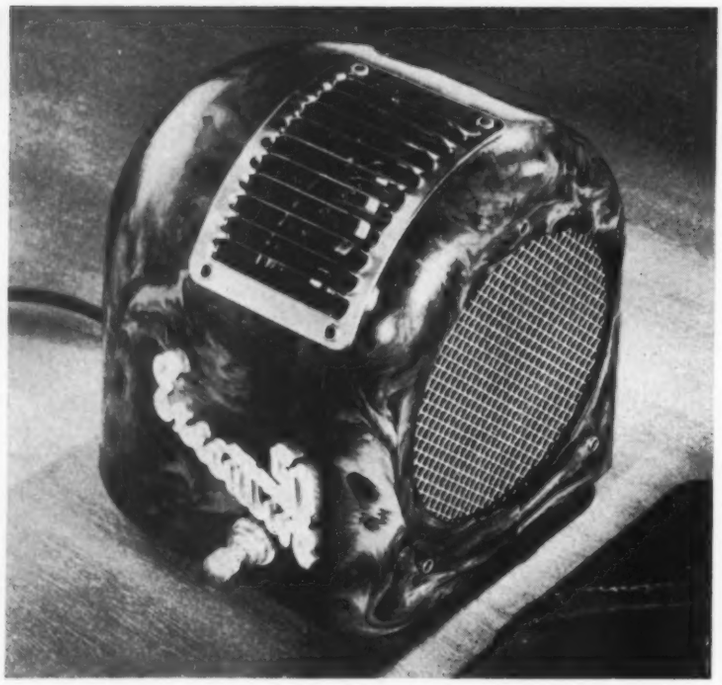






Magnetic Rollers Support Sheet on Shear

A SHEET support on the line of Cincinnati Shaper Co. shears, illustrated above, employs magnetic rollers to prevent the inaccurate back-gaging caused by sagging of stock during the cut. Support channels carrying Alnico permanent magnet rollers, as shown in the drawing above, are spaced along the length of the machine. The magnet rollers are free to turn in their supporting channels as the sheet is pushed into the shear, with no noticeable drag on the sheet. Cut pieces are automatically stripped from the magnetic support by action of the upper knife. The support is designed to handle all magnetic materials up to 16 gage thickness, with 36 or 48-inch back-gaging range. The shear shown in the photograph has a maximum capacity of 10 gage, 10 feet long. An inclined ram, straight-edge knives and hydraulic holddowns giving a uniform pressure the length of the cut also contribute to cutting accuracy.



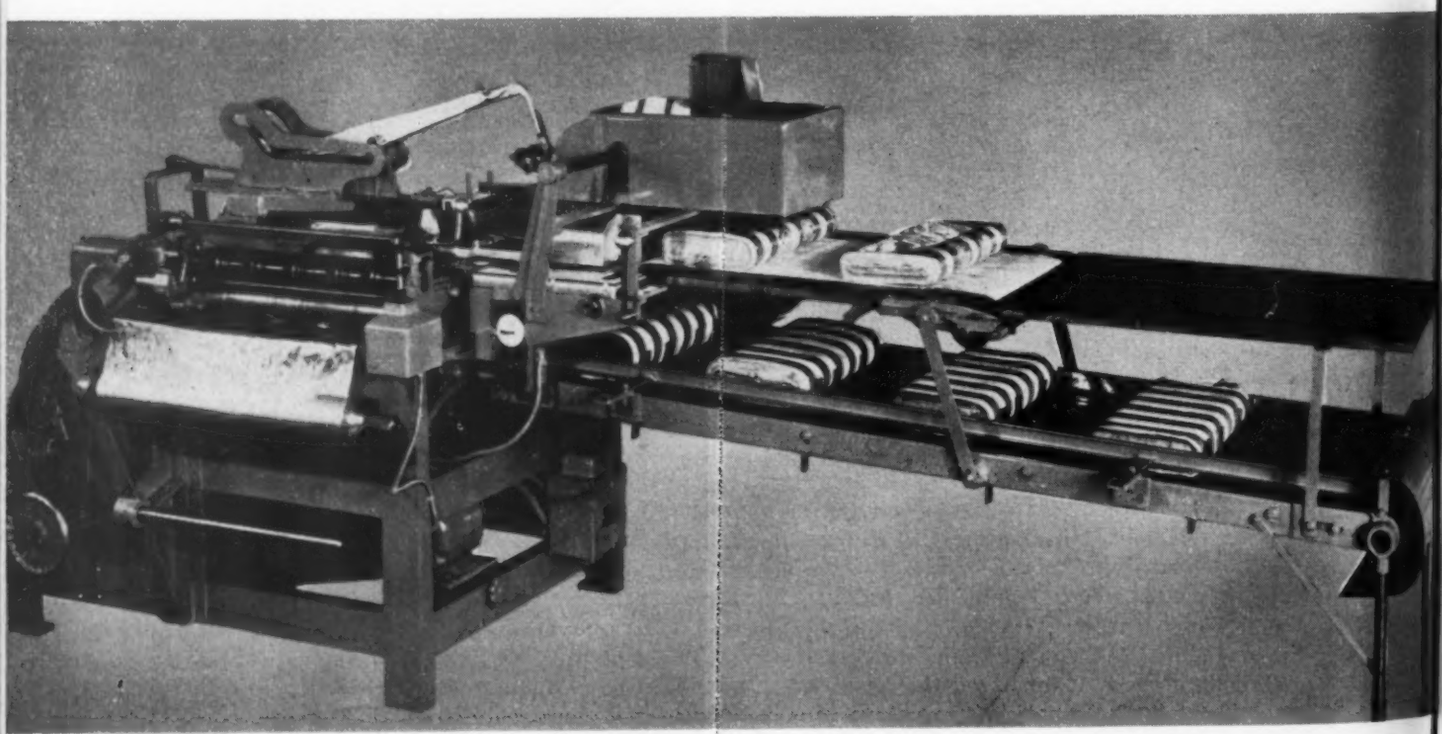
Contemporary DESIG

Office Air Circulator Fits Desk

A NEW concept in office air circulators, the National Reinforced Plastics Corp.'s portable fan, is shown in the illustration, left. The wheel type impeller provides a gentle air flow that will not disturb papers on the desk or cause gusts or drafts. Although equivalent to a 10-inch fan in quantity of air moved, the unit covers less desk area than a telephone, stands 5½ inches high and weighs 3¼ pounds. Modern case is of shatterproof Tenite.

Wrapper Automatically Packages Textiles

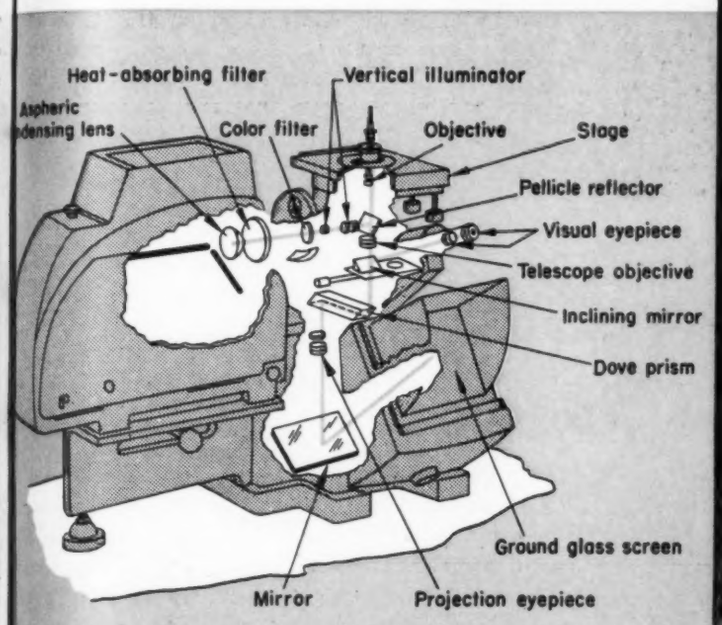
WRAPPING machine for automatic packaging of textile materials, using cellophane, polythene or pliofilm wrapping, is shown below. Made by Hayssen Manufacturing Co., the standard machine is designed for heat sealing. Other machines are available to wrap with acetate or kraft paper, using solvents or glue as the sealing medium. Material to be wrapped is loaded on an infeed conveyor (lower level in the photograph), with each package individually controlling the paper feed mechanism. Wrapping material is supplied from a roll mounted at one side of the machine. The required amount of sheet is unwound, cut to size for the particular package being wrapped, and folded and sealed around the package. The finished product is discharged from the machine on the upper conveyor at a speed of 20 to 30 packages per minute.

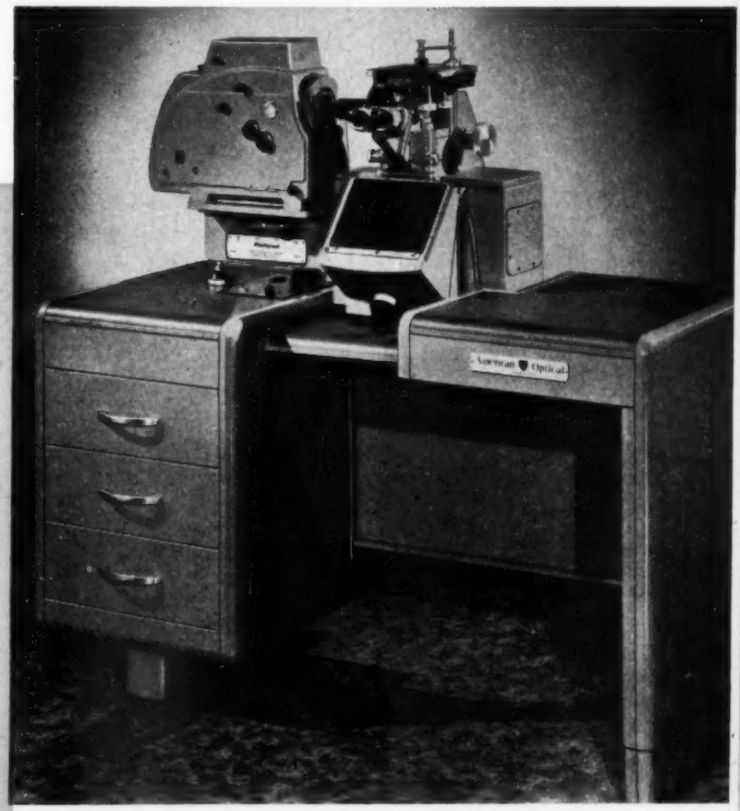


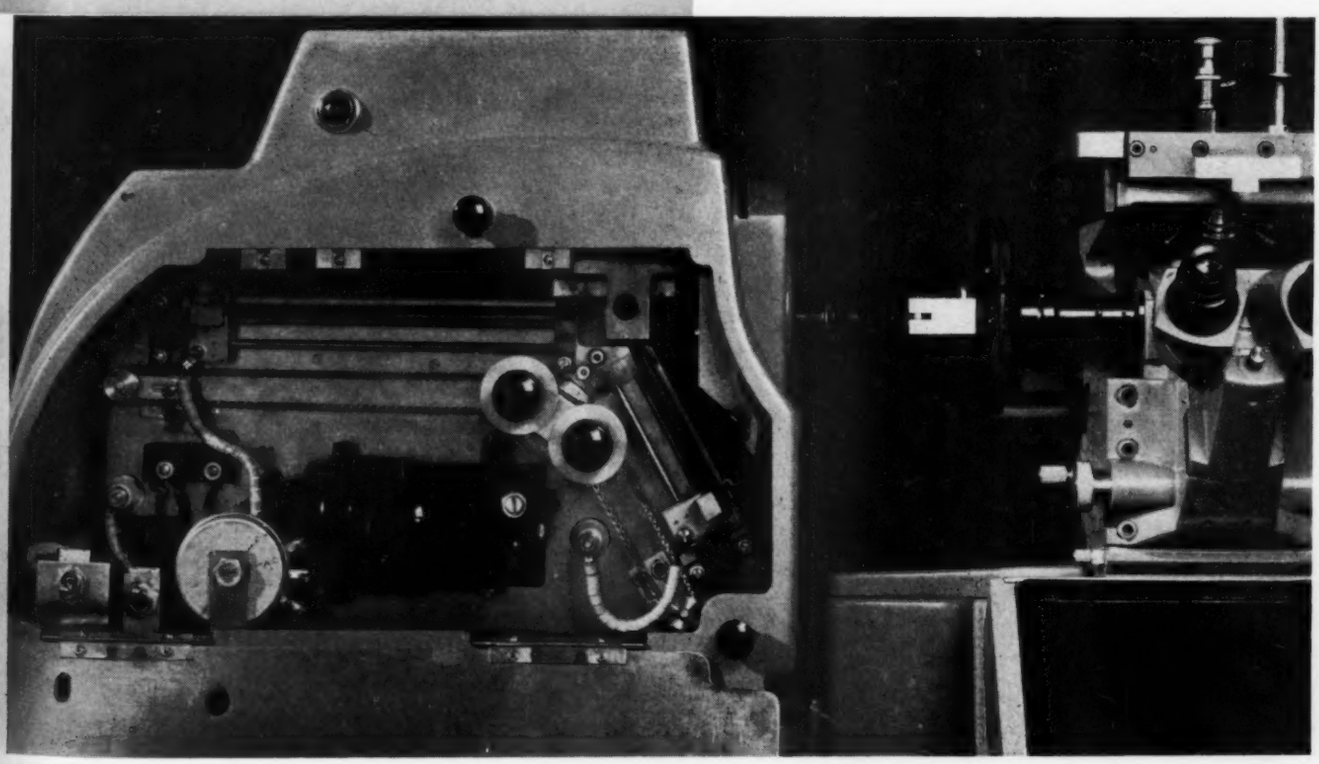
Metallograph Features Adjustable Carbon Arc

SUPERIOR optical performance is combined with convenience and simplicity of operation in the new Metallograph, right, designed for making routine photomicrographs for process-control purposes. Made by Instrument Division of American Optical Co., the equipment includes optical systems for photography and visual observation, coupled to permit all focusing to be done through the visual system, eliminating the necessity of ground glass focusing. The drawing, below, shows the path of light from a carbon arc lamp (or optional ribbon-filament lamp) to the visual eyepiece and viewing screen. Specimens are held in a mechanical stage mounted on ball bearings for smooth adjustability.

The housing of the carbon arc lamp has been opened in the photograph, bottom, to show the motor and drive for feeding in the carbon rods at a uniform rate to give the necessary steady arc. Adjusting







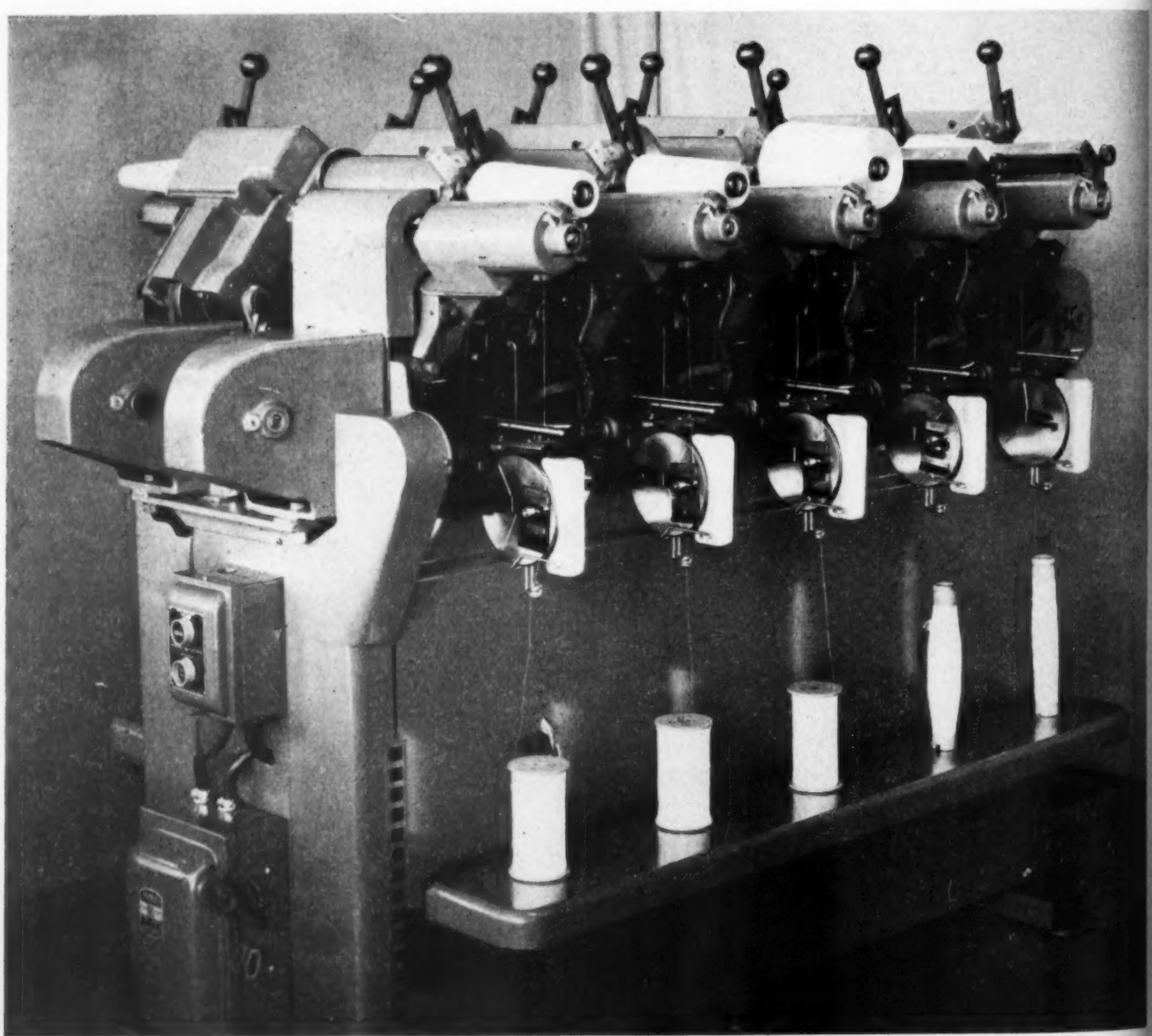
knobs provide for positioning the carbon arc unit laterally and in the vertical plane. The vertical rod is set at a 120-degree angle, which maintains a more uniform arc crater. A small glass viewing window permits an image of the arc crater to be seen, and a red warning light cautions the operator that the carbons are almost exhausted and that a new set should be installed before another picture is taken.

Standard magnifications are available in the range from 50X to 1500X, with four objective lenses carried in a revolving turret located just below the specimen stage. These lenses are all parfocal and parcentered, so that refocusing is not required when changing from one objective lens to another.

Thread Winder Uses Moving Spindle

REPRESENTATIVE of the swing of the textile industry to modern high-speed equipment, the precision thread winder, below, uses moving ball-bearing take-up spindles to wind at starting speeds of 400 yards per minute on a 3½-degree cone. Made by Universal Winding Co., the machine permits a straight thread line between supply and take-up spindles; during the course of winding the package moves horizontally relative to the thread guide. As the diameter of the package increases, the spindle frame is moved away from the thread guide by a builder cam. Speed of this movement is controlled by change gears selected according to thread size and, consequently, accurate density control is assured.

The tension device is a straight-line magnetic type equipped with a rotating plate which revolves at from 40 to 50 rpm, thereby lessening chances of clogging with most types of yarn. The machine can be built as a standard increasing-yarn-speed machine, as a constant-yarn-speed machine or as both combined.



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A postcard is included in this editorial section to help you obtain clip sheets of any article in this issue. In this way you may file articles of special interest and still pass on *Machine Design* to the next reader without disturbing its editorial content.

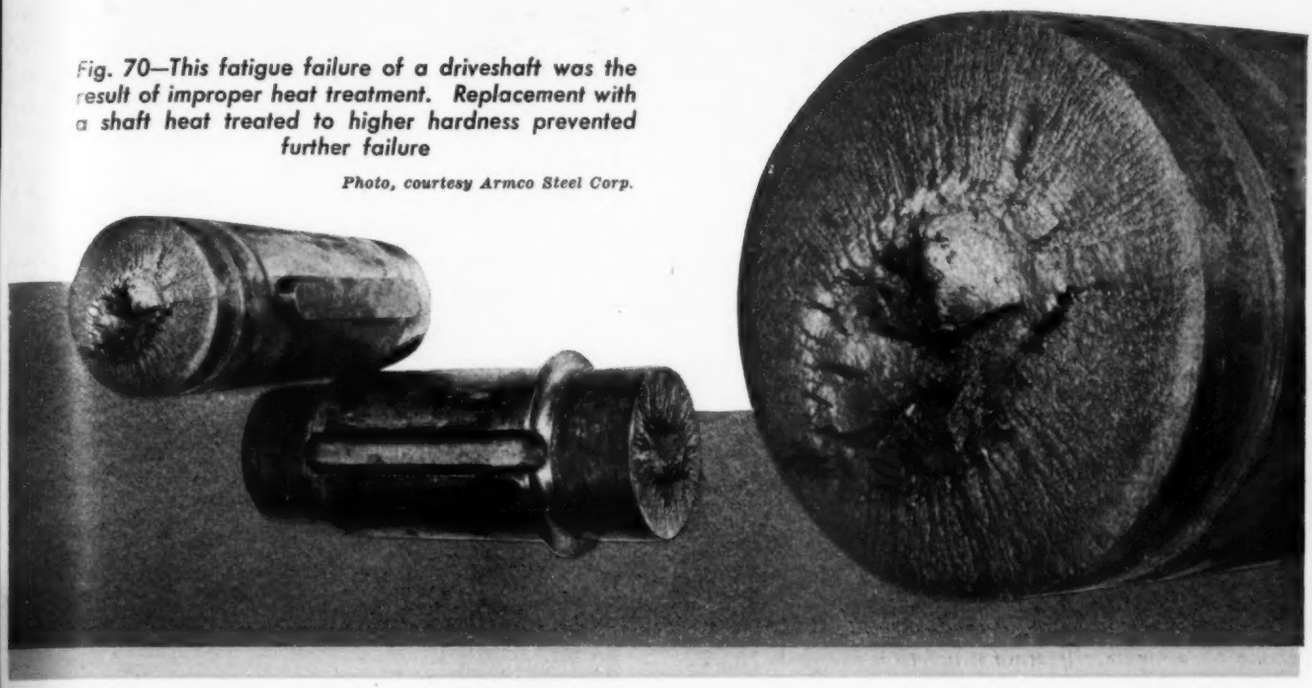


Fig. 70—This fatigue failure of a driveshaft was the result of improper heat treatment. Replacement with a shaft heat treated to higher hardness prevented further failure

Photo, courtesy Armco Steel Corp.

Why Machine Parts Fail

Part 8—When Not To Blame the Designer

By Charles Lipson
Consultant
Detroit, Mich.

LAST in the present series on fracture analysis, this article deals with failures caused by defective metallurgy, improper methods of fabrication and assembly, and other factors usually beyond the direct control of the designer. Failures resulting from defective design were discussed in last month's article.

Although fully 30 per cent of service failures in several representative industries have been attributed to the designer, the remaining 70 per cent can be traced to circumstances that are not his responsibility. Among these are such factors as improper heat treatment, accidental bruising of the finished part, substandard material, roughly machined surface, and various unexpected service conditions. *Fig.* 70 illustrates the fracture of a driveshaft from a spiral weld pipe machine. Although this fracture occurred at a small but sharp change in section, it was concluded that the underlying cause was failure to develop the full strength of the steel by proper heat treatment. No further failures have been reported since replacement with a properly heat-treated steel.

A number of the more representative failure causes, clearly beyond the control of the designer, and typical case histories are presented in the following discussion.

SURFACE DECARBURIZATION: Surface decarburization can be especially critical in leading to fatigue failures because the reduction in strength due to loss of carbon occurs where the stress is usually greatest—at the surface. This condition is probably most important in springs. In fact, it has been said that the relative superiority of certain alloys for springs, as regards fatigue properties, is based primarily on the superior resistance of such alloys to decarburization[1].

Thus failure of a member in an area of no evident stress concentration should not be dismissed lightly as overstressing when it may be a case of reduced surface strength due to decarburization. On a hardened steel spring, a relatively shallow layer of decarburization at the surface may soon develop fatigue cracks under repeated high stresses. The crack or

[1] References are tabulated at end of article.

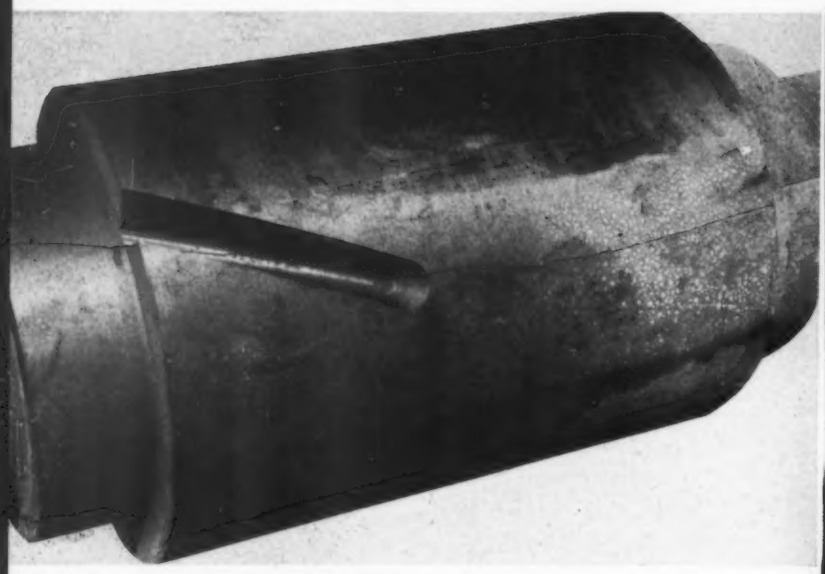


Fig. 71—Above—Improper heat treatment caused residual stresses which cracked this semimachined forging of a rolling mill drive pinion when the initial cut was made for the pinion teeth. Internal structure is shown in Fig. 72

Fig. 72—Right—This sectional view of the pinion shown in Fig. 71 reveals, by the absence of internal ruptures near the outer surface, that residual stress had not been relieved

Photos, courtesy Republic Steel C

cracks then act as notches to cause stress concentration, with a resultant overloading of the full-strength material adjacent to the decarburized layer and, finally, fatigue failure. It should be kept in mind that a fatigue failure occurring in the immediate vicinity of an obvious design stress concentration may be due to both stress concentration and surface decarburization. This point is well illustrated in an article by McBrian and Archibald discussing failures in railroad track and cars[2]. Horger and Lipson also present data demonstrating the harmful effect of decarburization on the fatigue strength of automotive rear axle shafts[3].

QUENCHING CRACKS: Among the numerous metallurgical factors that can precipitate fatigue failures, should be mentioned quenching cracks. These cracks, the result of drastic quenching, cause local stress concentrations and can, of course, lead to fatigue cracks and ultimate fracture. Scott found that it was possible to obtain quenching cracks in ¾ to 1½-inch diameter cylinders by water quenching[4]. Upon examination of fractured pieces, it may be quite difficult to determine whether the crack initiation was due to quenching practice, but in severely quenched pieces this possibility should be given full consideration. Failures from this cause can, however, be minimized by inspection of pieces, prior to placing in service, by the various crack-detection methods such as Magnaflux, Zyglo, and mild etching.

INCLUSIONS: Inclusions also represent structural discontinuities; those at the surface of the material are very much more detrimental in their effect on the endurance limit than inclusions deeper in the metal. The effect of inclusions is more serious as the hardness of the steel increases. J. B. Johnson was convinced that "large inclusions, or a cluster of many small ones, may reduce fatigue strength by about 15 per cent when the ratio of the depth of the inclusions in a radial direction to the diameter of the specimen is approximately one to ten"[5]. Evidently inclusions are most dangerous when located at fillets or other highly stressed locations. When a fatigue crack starts, it tends to progress from one inclusion to another. There is a natural tendency to ascribe any fatigue failure to inclusions if metallographic examination reveals an inclusion anywhere in the piece, no matter how far the inclusion may be from the nucleus of failure. Tiny inclusions often present in well-made steels have only about the same effect as a surface scratch of the same dimensions. Inclusions in general are much less serious than such stress raisers as meager fillets, oil holes and other geometric discontinuities.

Inclusions Less Significant in Soft Steel

As with other defects, discontinuities in a metal are more serious the harder the steel. Extreme cases have been observed where inclusions are held responsible for dropping the endurance limit of a hard steel from 80,000 to 64,000 psi. In soft steels the effect of ordinary small inclusions is very slight. For these reasons "dirty" steel should be avoided particularly for use in hard, highly stressed parts.

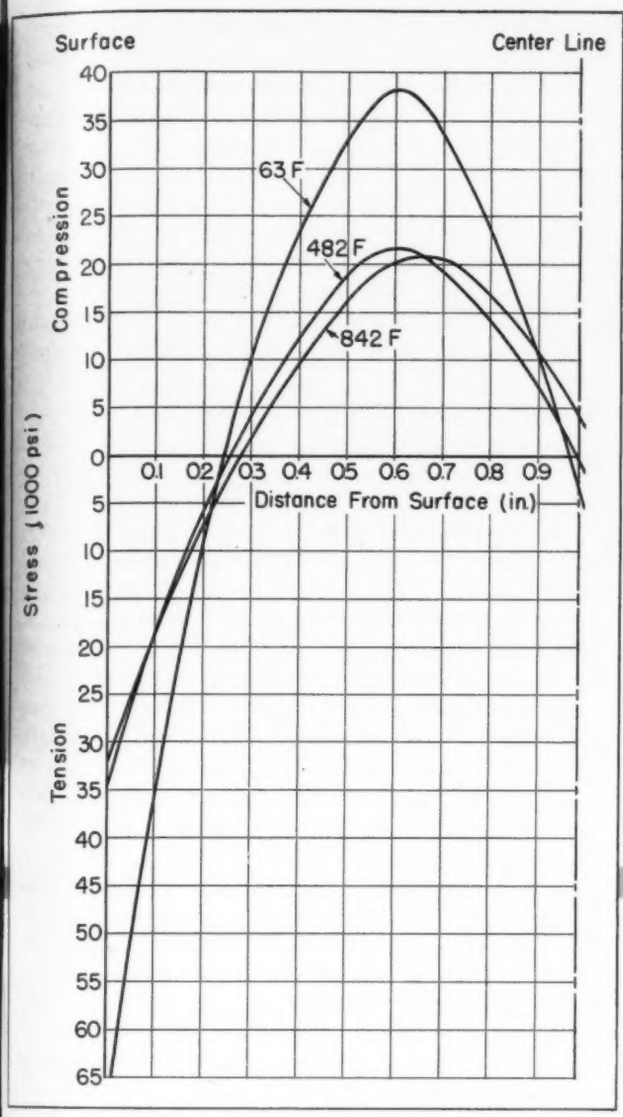
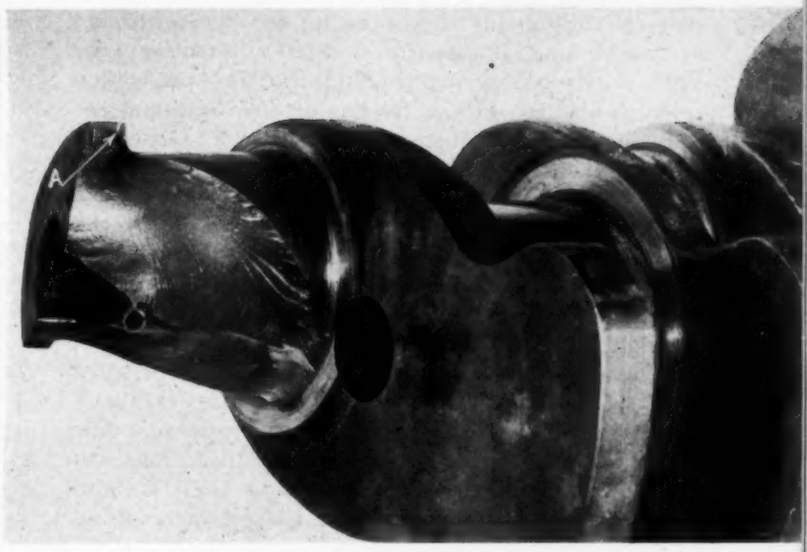


Fig. 73—Left—Effect of straightening temperature on residual stress for heat-treated parts is shown by this graph from Reference 9



Photo, courtesy International Harvester Co.

Fig. 74—Above—Fatigue failure of this crankshaft was caused by a grinding crack indicated by (A). Combination of a grinding crack and a fillet is an almost certain fatigue failure source

The slag inclusions sometimes found in welds can also be detrimental to the fatigue properties of parts fabricated by this method.

CASTING DEFECTS: Castings are subject to several defects, associated with the casting process, that can lower the strength of the material, either locally or generally, below the calculated level. Blow holes, shrinks, hot tears and cracks, and inclusions are just a few of the imperfections apt to be encountered. The American Foundrymen's Association has compiled a detailed analysis of the common casting defects, including a study of the factors that produce each, as well as many illustrations for the identification of these defects[6]. The AFA analysis finds that most casting defects can be attributed to the pouring operation with molding practice, cores, and sand each following closely behind as major factors in causing poor castings. Approximately 9 per cent of the casting defects found were attributable to the designer.

HOT SHORTNESS: Steel can become *hot short*—brittle at temperatures of 475 F or higher—due to the absorption of copper and other metals. Williams cites an interesting case of this type in which fatigue fracture was originated by a sudden surface crack to the depth of copper penetration[7]. This crack then propagated itself under the imposed repeated stresses until complete failure occurred. There was no indication of flaws in the material, but a metallographic study indicated absorption of copper at the surface.

RESIDUAL STRESSES: Presence of residual stresses in the finished piece, due to heat treatment or fabrication methods, can be either harmful or beneficial to the fatigue life of a machine part. Residual tensile stresses can manifest themselves in either mechanical or chemical effects. Mechanically, cracking or warping of the part is caused. Chemically, grain boundary corrosion is caused and may result in complete loss of boundary cohesion. Much research work on residual stresses has given some knowledge of how and why they occur and means of measuring their intensity. In examination of a fracture, however, there may be little evidence pointing to the existence of a residual stress. It is then necessary to study the history of the part from the ingot to the finished piece. Heat treatment (including quenching practice), drawing or rolling, cold working, cold straightening, and other fabrication processes may all result in residual stresses.

Occasionally residual stresses due to heat treatment may be sufficient to cause a perceptible crack before the part is ever placed in service. An example of this circumstance is the rolling mill drive pinion pictured in *Figs.* 71 and 72. Residual stresses in the heavy section apparently were instrumental in causing the stress crack which developed and spread dur-

ing the initial cut in machining the pinion teeth.[8]

Horger and Lipson found that automotive rear axle shafts cold-straightened during the production process demonstrated a 25 per cent loss of endurance limit compared to unstraightened shafts[3]. In evaluating the magnitude of residual stresses induced by cold straightening, they observed residual surface tensile stresses as high as 120,000 psi. It has been found, as illustrated in *Fig.* 73, that the severity of residual stresses induced by the straightening operation varies with the temperature at which the straightening is done[9]. This plot demonstrates that the magnitude of residual stresses can be reduced 50 per cent by performing the straightening at 482 F instead of at room temperature. However, this does not mean that the fatigue strength will increase correspondingly. The plot also indicates that straightening at temperatures above 482 F gives insignificant improvement.

Residual Stresses Most Harmful in Hard Steel

As with many other factors, the weakening effect of residual stresses is much more pronounced for hard brittle steels than for ductile steels. Through their inherent plasticity, ductile steels are capable of internal stress relief upon cyclical load application.

TOOL MARKS: It is common knowledge that rough machining can often initiate fatigue failure in highly stressed machine parts. Each groove left by the cutting tool acts as a stress concentration and becomes a candidate for the nucleus of a fatigue crack. This effect is intensified if a generally smooth surface is marked by a few isolated tool marks. The presence of a multiplicity of similar stress concentrations, as in a threaded part, has a slightly alleviating effect. Because endurance limit increases with improved surface finish, surfaces of severely stressed aircraft parts are usually highly polished.

Close examination of the fractured part may sometimes be necessary to detect a tool mark as the cause of failure. The surface in general might be smooth with only a single deep tool mark that probably coincides with the plane of the fatigue fracture and loses its identity upon fracture. Rough machining is apt to be most dangerous in fillets and other regions where some stress concentration already exists and is, of course, most critical in hard notch-sensitive steels.

GRINDING CRACKS: Cracks in otherwise sound material can also be caused by severe grinding operations. These cracks, once formed, naturally act to decrease the fatigue strength of the part. The heat and pressure resulting from contact of grinding wheel and steel may be sufficient to cause either residual stresses or actual cracks. In hardened steels, cracks may be the result of proper grinding of an improperly heat-treated part, or of improperly grinding a correctly heat-treated part. Surface cracks arising during the grinding process are most prominent and most harmful in hardened steel. Formation of grinding cracks varies with composition and hardness of the steel being ground, surface speed of grinding, rate of material removal, and various factors involved in the structure of the grinding wheel.

Shown in *Fig.* 74 is a crankshaft fatigue failure which originated at a series of grinding cracks in the fillet region. At *A* in the illustration is the grinding crack which was the nucleus for the fracture.

Tarasov points out that in spite of their comparative shallowness (often not more than 0.0005-inch), cracks in a ground surface can rarely be removed in

Fig. 75—Comparison of endurance limits for as-forged surface with ground and polished surface is shown in this study by Lipson and Noll

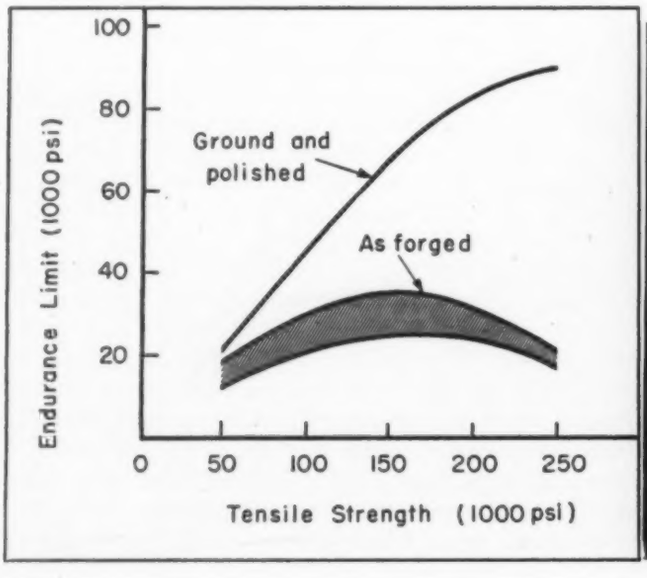
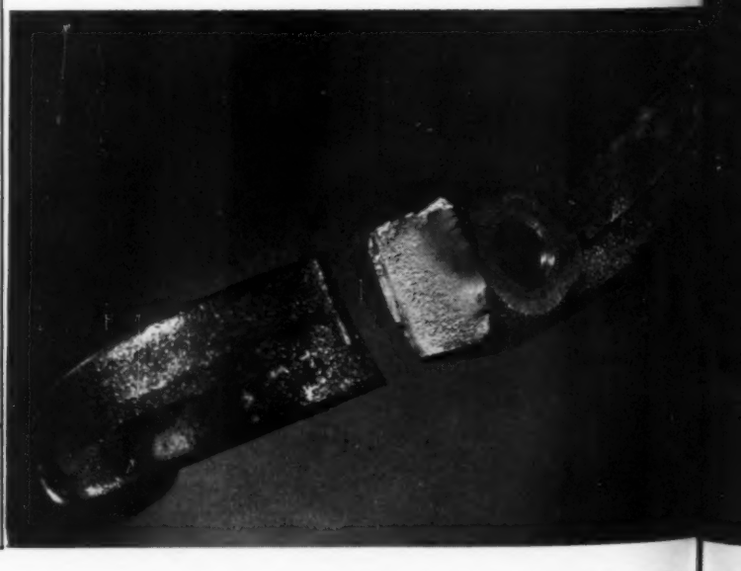


Fig. 76—Failure of this steel forging during fatigue test was caused by the rough decarburized surface in combination with the sharp corner

Photo, courtesy Ford Motor Co.



ordinary practice, either because of insufficient stock left for grinding below the crack bottoms or because the cracks keep propagating themselves deeper while they are being ground away[10].

ROUGH SURFACES: Rough surfaces on machine members, such as those left on unfinished forgings, are detrimental to fatigue strength. The endurance limit of such a part will be considerably below that for the same steel in the form of a smoothly polished laboratory test specimen. The accompanying graph, *Fig.* 75, demonstrates the reduction of fatigue strength associated with an as-forged surface compared to a polished surface.

Several Faults May Be Present

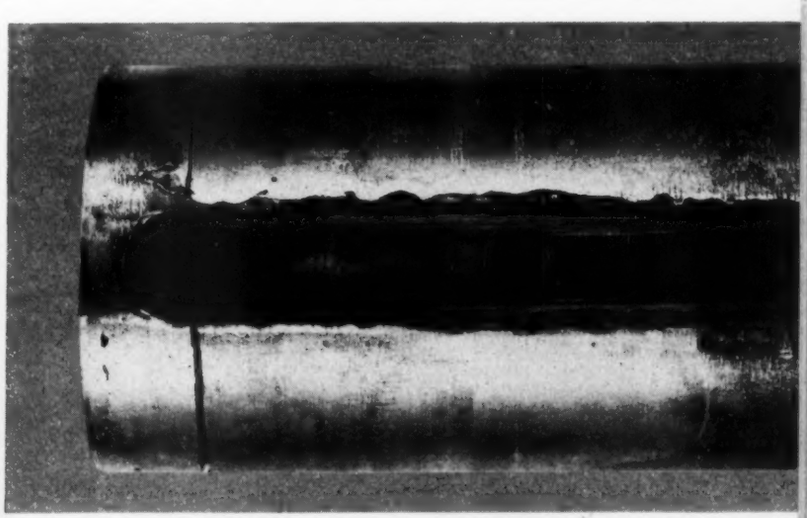
The harmful effect of the as-forged surface is actually due usually to a combination of such factors as roughness, oxide scale defects, and surface decarburization. Inadequate fillets, sharp external corners and other geometrical stress raisers will serve to amplify the effect. *Fig.* 76 is a photograph of a forged arm which failed in fatigue. It is evident that the rough forged surface, in combination with the sharp corner at the edge of the flat surface, contributed to initiation of the fatigue crack.

FORGING DEFECTS: Common defects inherent in the forging process, including such phenomena as forging bursts, pipes, laps and seams, all act as discontinuities and, hence, local stress concentrations. If these occur near the surface, as seams and laps often do, the effect is especially pronounced in reducing the fatigue strength of the part. Forging of shanks on large masses of steel should be smoothly done where sections change in size. Sharp local depressions and roughly finished radii act as seeds for the initiation of fatigue cracks. Any fractured piece with surfaces left in the forged condition should be inspected carefully with these facts in mind.

Illustrated in *Fig.* 77 is the failure of a steamship paddle-wheel drive shaft. This shaft had been in service for approximately 10 years when an audible "squeaking" was noted. Examination revealed a large spiral-shaped crack on the surface of the shaft extending for a considerable length. The crack was multiple in nature with loose pieces between the cracks.

The shaft was a large forging of plain carbon steel, approximately SAE 1040, and had been liquid quenched. Further examination showed numerous radial cracks, with the fractures covered with rust, extending from the center outward to within 2 to 3 inches of the surface. There were also indications of decarburization along the borders of the rusted portion of the fracture, from which it can be assumed that the cracks were present at high temperature. Although the steel contained a large amount of nonmetallic inclusions it was felt that the failure was initiated at the time of fabrication by a secondary pipe in the ingot.

WELDS: It has been said of welded joints that they are subject to almost all types of stress concentration that can be thought of in relation to ordinary design plus some of their own. Although a great deal of work has been done in studying the stress concentrations that often accompany the welding process, poor welding practice is still by far the chief cause of failure of welded assemblies rather than any stress concentration associated with the weld geometry. Weld defects may be in the form of internal voids, rough beads, large slag inclusions, lack of fusion, and shrinkage cracks, to name just a

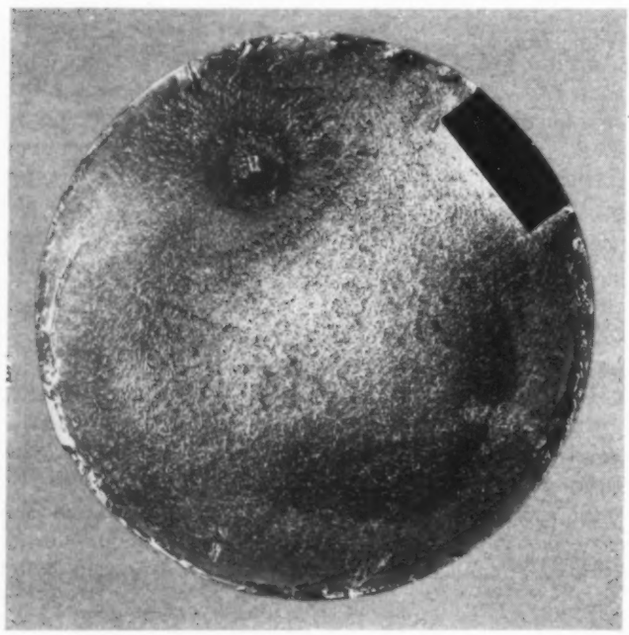


Photo, courtesy Republic Steel Corp.

Fig. 77—Left—Torsional fatigue failure of this steamship shaft was caused by forging defects. Many radial cracks resulted from a secondary pipe in the ingot

Fig. 78—Above—This undersized shaft was salvaged by welding. Improper heat treatment after welding gave a brittle peripheral zone which caused the fracture

few. Particular attention should be paid to the rate of cooling after welding if the steels being welded are capable of air hardening; otherwise a very brittle martensitic structure may result in the vicinity of the weld. This latter point is illustrated in *Figs.* 78 and 79 which show a rolling mill lineshaft failure. This shaft had been built up by welding after having been machined too small in diameter. The heat of welding had been extracted from the weld at a rate sufficient to produce a 3/16-inch deep peripheral martensitic zone. As indicated in *Fig.* 79, the fatigue failure apparently originated at several points in this outer zone and progressed rapidly through the shaft. The fracture surfaces gave no evidence of internal defects in the steel.



Photo, courtesy Republic Steel Corp.

Fig. 79—Above—This fracture surface of the shaft shown in Fig. 78 reveals that, even though a stress-concentrating keyway is present, fracture started around the entire surface of the part

Fig. 80—Below—Fatigue failure of this shaft occurred through a section left brittle by a weld applied to compensate for previous wear

Photo, courtesy Armco Steel Corp.

SALVAGING OPERATIONS: Many times, in the process of repairs or modifications in the shop, insufficient attention is given to stress considerations. It often happens that these changes do not pass through the engineering department. This process may lead to failures because of lack of appreciation of the many small details in fabrication that can lead to critical stress concentrations or residual stresses.

Failures Due to Salvage by Welding

Many parts are salvaged by welding: joining the two halves of a fractured part or building up material to replace that removed by wear or by a machining error. Several failures have been encountered in which injudicious welding practice during the salvaging operation was primarily responsible for subsequent failures[1].

In *Fig.* 80 is illustrated the fracture of a well-pump shaft attributed to rapid cooling of a welded area. This ½-inch diameter shaft broke after 8 years of service in a centrifugal deep-well pump. The failure occurred at a point where the surface had been built up by weld deposits because of wear in a previous service period. The material was plain carbon steel with a microstructure indicating that the shaft had been normalized. The hardness varied from 160 bhn in the base metal to 240 bhn in the weld deposit and the zone affected by the heat from welding.

Lack of fusion, defects in the deposited weld metal, use of improper welding electrodes, and other examples of poor welding practice are frequently found to promote fatigue failures through reduction in the strength of the material or the introduction of cracks or residual stresses.

Many other factors beyond the province of the designer could be given as potential causes of failure, such as corrosion, heat checks, unsuspected resonance vibration, etc. A large number of influences are listed in Reference 1. Thus, identification of the cause of failure of a machine part may be a simple task or a difficult one, depending on the multiplicity of influences. One point stands out clearly. A fractured machine part deserves respect.

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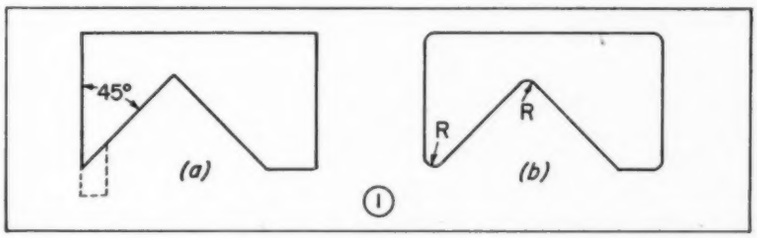
DESIGN DETAILS

for Stamped Parts

By Dayton A. Rogers
President
Dayton Rogers Manufacturing Co.
Minneapolis, Minn.

Specifications of Flat Stampings

AS A STAMPING is shown on a drawing, it is commonly understood that the burr side is up, unless otherwise specified. Quite often it is important that the burr side be specified on the individual part drawing. This is not necessary, however, should the stamping be of such design that it can be turned over to give the burr side the correct position when the piece is assembled.



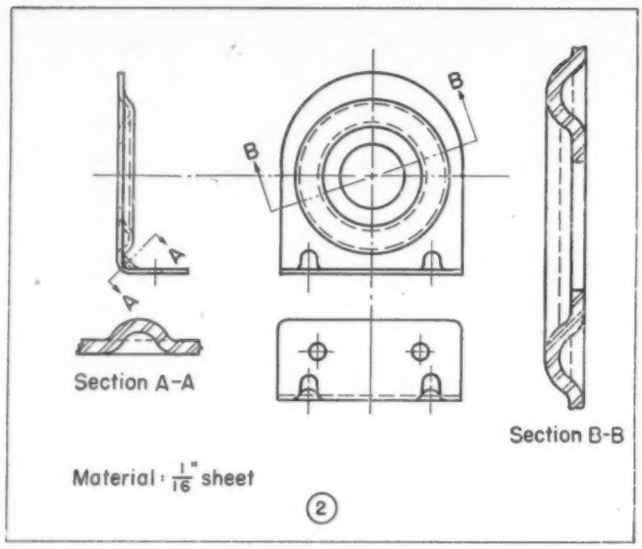
While parts *Fig.* 1*a* and *b* are essentially the same, should design permit, there should be a slight radius on all corners. This would increase the die life considerably, with the possibility of adding to the general appearance when the piece is used in the assembled unit. It is considered impractical to attempt a sharp corner as in *Fig.* 1*a*. This would shorten the punch life considerably and give an unsatisfactory finished section, particularly if the blank had any thickness whatsoever.

Should a sharp section be necessary on a finished blank, the blank could first be produced as shown by the dotted lines, and a second operation added to remove the excess material to give the finished blank the desired shape and size. With the short-run stamping method, an individual blanking die would be produced to make either *Fig.* 1*a* or *b*, and no universal tooling would be used. This of course would make it possible to produce the blank as at *b* with any desired radii or contour without additional cost.

Stamped Re-enforcing Ribs

WHILE re-enforcing ribbing or stiffening ribs in stampings are not new, sometimes their possibilities are overlooked in part design. It is generally found in a bent sheet-metal part, where it should be the stiffest, it is usually the weakest. One or more stiffening ribs, such as section "A-A" *Fig.* 2, at the right-angle bend increase the rigidity of the part about 100 to 200 per cent. Such ribs or corrugations can be twice the thickness of the material in their overall height, and the inside radius of the rib, if design permits, should be equal to the stock thickness.

Quite often, the large hole shown is merely introduced to lighten the part. However, should the hole be for a definite design purpose, a corrugation or rib ("B-B") may be easily thrown around the

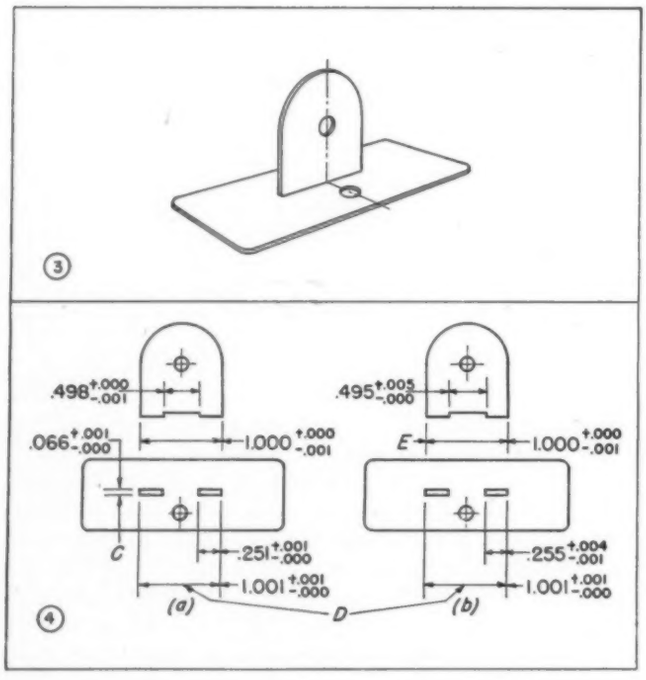


hole halfway between the outside of the piece and the hole.

Such ribbing and corrugating on parts should not be too close to the periphery of the blank; otherwise, there is a possibility of distorting the profile or contour. All such corrugation and ribbing should be as far as possible from the profile of any of the pierced holes or contour of the blank itself. This is due to the fact that the contour of the blank is first produced, the holes pierced in the second operation, and the ribbing and corrugating, including overall forming put in as later operations.

Production economy can be attained in design by keeping the ribbing and corrugating as far as possible from the pierced holes and blank profile and, in addition, least distortion of both holes and profile during forming operations is best assured.

Tolerance Specifications on Mating Parts



TWO die-cut parts completed the assembly shown in *Fig.* 3. It was most important, however, that the two holes in these parts, after assembly, be as accurate as possible and in perpendicular alignment. In the production of these two parts, the only close tolerances which had to be held were dimensions *C, D* and *E, Fig.* 4.

Specifications as first submitted, *Fig.* 4*a*, do show rather close tolerances. But tolerance accumulations would cause some discrepancy in the relationship of the two holes after assembly. *Fig.* 4*b* shows relatively the same two parts with more generous clearance in the mating of the two pieces before final assembly, but still maintaining the same relative accuracy and tolerance as to hole alignment. With the latter specifications, these two parts were staked together with the desired degree of accuracy at considerably less cost.

In dimensioning stamped parts, observation of this principle will assure maximum production economy. All dimensions should be studied to permit maximum latitude. Only those absolutely necessary should be specified with the minimum practicable limits.

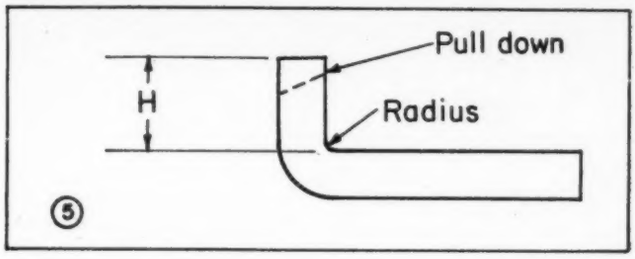
V-Form With Minimum Material Margin Or Minimum Height

IT IS OFTEN desirable to produce a given formed part with minimum overall height on the right-angle formed section. As simple as this operation appears, the overall right-angle bent section has limitations as to its height. Depending upon the material thickness, material temper, and physical properties of the sheet alloy being bent, the following are suggestions to be considered as minimum on such operations.

Minimum Height *H* of Bend

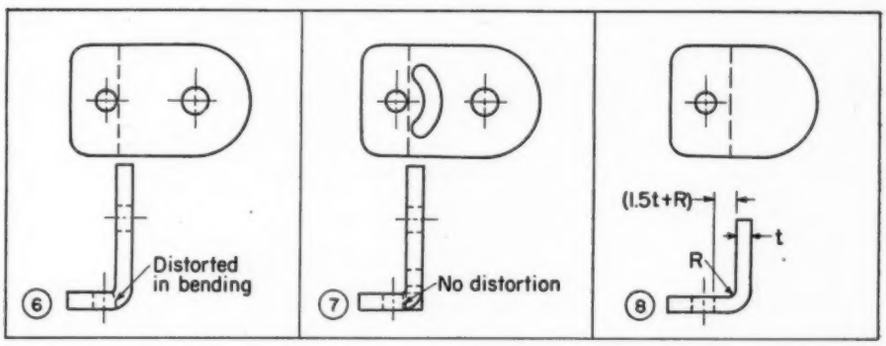
Stock Thickness	Bend Radius				
	Sharp	1/32	1/16	3/32	1/8
0.032	0.050 to 0.062	0.093	0.125	0.156	0.187
0.062	0.093 to 0.115	0.140	0.160	0.187	0.265
0.093	0.156	0.189	0.205	0.250	0.266
0.125	0.250	0.280	0.292	0.315	0.330
0.156	0.300	0.315	0.340	0.360	0.370

Should the overall height H be less than that shown in this table, considerable pull-down, such as indicated in *Fig.* 5, will be introduced until there is practically a sharp edge on the bent section. Should less height be necessary on the finished stamping than shown in the table, secondary machining operations, such as trimming, milling, etc., will have to be considered to give the part a square-edge finish.



Pierced Holes Close To Right-Angle Bends

OFTEN it becomes necessary to have a hole as close to a right-angle bend as possible, such as shown at *Fig.* 6. To get a normal hole at the right-angle bend, it must be pierced *after* the part is formed to shape. Otherwise, a distorted hole will occur as indicated in *Fig.* 6.



The same blanked and pierced part redesigned with the addition of a crescent slot is shown in *Fig.* 7. This design allows the part to be die-cut, blanked and pierced. There is enough flat material left around the desired pierced hole so that no distortion of material thickness affects the finished hole in the bending operation that follows.

While this design is not always permissible, it is quite often entertained from the standpoint of mass production, and it should be used with short pilot runs for developing part specifications in the event conventional type tooling is to be eventually employed. Stock left adjacent to the hole, of course, cannot exceed the material thickness of the stamping specification.

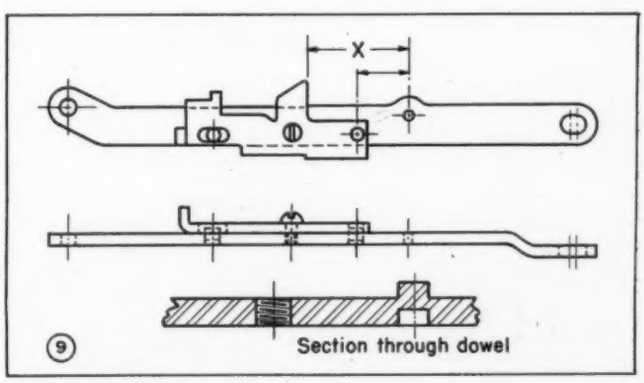
Fig. 8 shows the desirable location of a hole adjacent to a right angle bend. The edge of the hole should not be closer than one and one-half times the thickness of stock, plus the inside radius of the right angle bend.

Extruded Dowels For Mating Parts

DOWELING of two mating parts is usually introduced for holding a definite relationship from a given point on one part to a given point on the mating part. In this particular case, *Fig.* 9, it was most important that the dimension X be maintained, to assure accurate relationship between the two parts to as high a degree as possible at the lowest practicable cost.

Although the two dowels were extruded in the larger part, the location of the dowel shown enlarged and the hole in the mating part were the determining factors in holding dimension X. The second dowel was placed as far as possible from the first, and merely maintained the alignment.

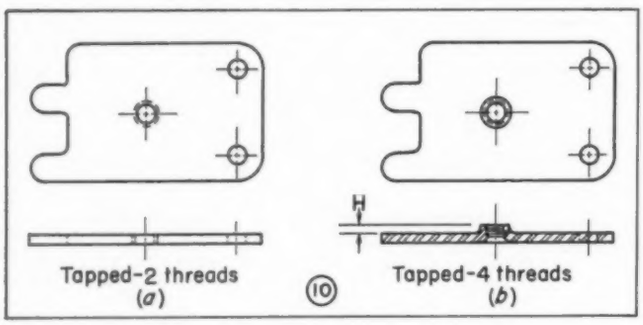
It should be remembered that there is bound to be some accumulated error in the diameter of the dowels, the diameter of the holes and the spacing of the dowels and holes. This was compensated for by piercing an elongated slot for the alignment dowel. All that is necessary is to maintain the correct diameter of both dowels, correct diameter of the mating hole,



and the correct width of the elongated hole. Such technique made it possible to assemble the small piece without selection and either spot weld or screw the mating parts together. The extruded dowels protrude through the mating part about one-half the thickness of stock.

Extruded Holes For Tapping

IN THE piercing and tapping of sheet metal stock, it is often advisable to use an extrusion at the point of tapping. Ordinarily, the maximum height *H* of the extrusion cannot exceed one-fifth of the body size of the tap. The material hardness should not exceed half-hard temper.



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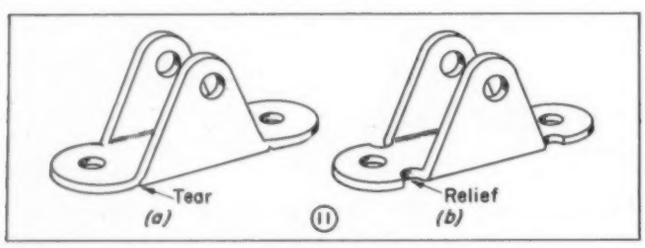
It can be seen by glancing at *Fig.* 10*a*, that only two threads could be produced, assuming this was an 8-32 thread. However, in *Fig.* 10*b*, 3½ to 4 threads would be possible, with an extrusion. Should conditions warrant, instead of using an 8-32 screw, a 10-32 thread should be employed, thus increasing the size of the hole and increasing the height *H* of the extruded section before tapping.

Since wall thickness in hole extrusion is approximately 75 per cent of the original stock thickness, it is advisable on lighter gages to use as fine a thread as possible to prevent break-through.

Right-Angle Bends

SIMPLE as it may be, the location of a right-angle bend to the major profile of a given blank may be most important. It is commonly understood that if the outside of the bend is parallel with the profile of the blank, regardless of the radius, a certain amount of fracturing or tearing of the material will be introduced, *Fig.* 11*a*. This amount of tearing will be increased or decreased, depending upon the radius on the outside of the finished formed part. This radius is increased or decreased depending upon the thickness of the material, together with other forming requirements.



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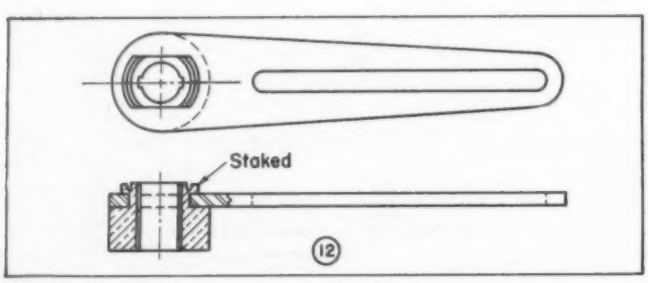
A common method to correct the fracturing or tearing tendency can be obtained by introducing notches for relief, such as shown at *Fig.* 11*b*. These relief notches can be produced in the profile of the flat blank, and should be twice the thickness of stock in width and twice the thickness of stock in depth, when design permits. The latter blank design gives a more satisfactory bend and greater rigidity in the bent section as applied to the major profile of the blank itself.

Round Pierced Holes With "Flats"



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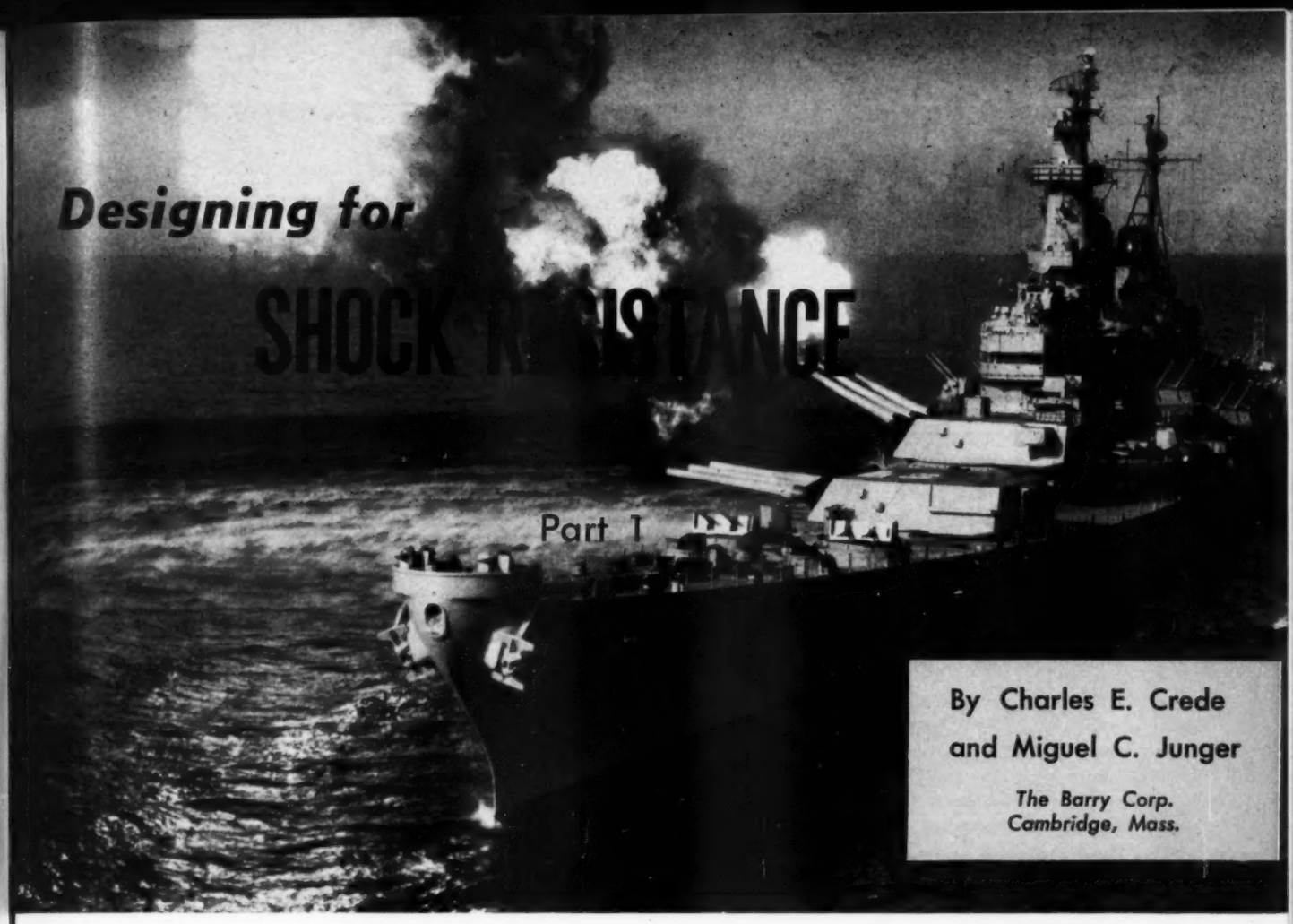
OFTEN it is necessary to stake together a screw machine part to a stamping such as that shown in *Fig.* 12. While one flat on the shouldered bushing is satisfactory, in some cases two flats on a shouldered bushing cost no more to produce, due to the fact they can be straddle-milled in one operation, permitting twice the holding power when such parts are staked together. The pierced hole in a blank with two flats also costs no more.



Designing for SHOCK RESISTANCE

Part I

By Charles E. Crede and Miguel C. Junger

The Barry Corp. Cambridge, Mass.

Official U. S. Navy Photo

WHEN upon the advent of World War II, the urgent need arose to procure shock-resistant equipment in large quantity, the mechanics of shock damage was only imperfectly understood. Urgency of the requirements precluded thorough analysis of the problem and the most expedient method of meeting requirements was adopted. This consisted of empirically designing equipment to withstand the shock imposed by high-impact shock-testing machines. Cut-and-try methods were used extensively. Shock-resistant models of many types of equipment were developed in this manner, and a number of principles were evolved that contribute to good shock resistance. These principles are generally applicable, not only to military equipment, but to any equipment required to withstand shock. The principles that relate to shock resistance of structures are discussed in this and a subsequent article. Information for these articles has been provided by the Bureau of Ships, Department of Navy.

DECREASE OF USELESS WEIGHT: One of the primary principles in the design of shock-resistant equipment is to maintain the weight of components as small as possible, and the strength of structural members as great as possible. Under the influence of shock, the forces applied to the structural members consist largely of inertia forces, and the magnitudes of these forces are directly proportional to the masses from which the forces are derived. This principle becomes more important as the distance from the base

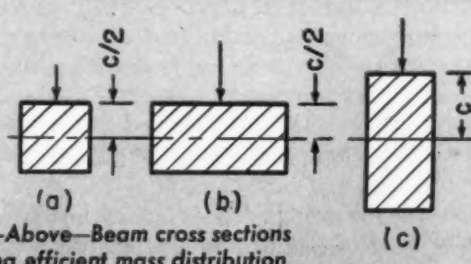


Fig. 1—Above—Beam cross sections showing efficient mass distribution

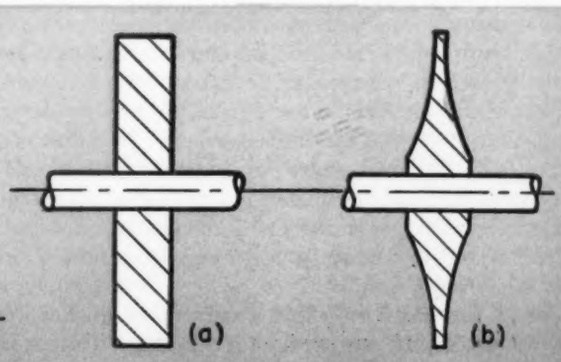


Fig. 2—Right—Turbine rotors illustrating optimum design (b) compared with higher stressed design (a)

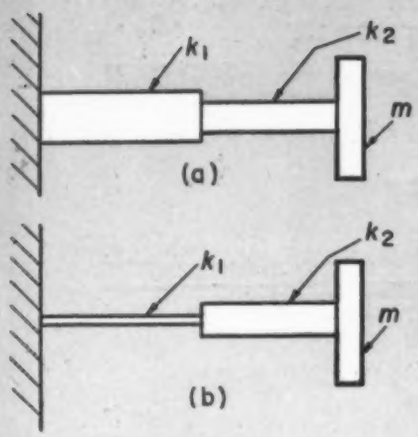


Fig. 3—Shock resistance of cantilever beam system improved by increasing flexibility of base member

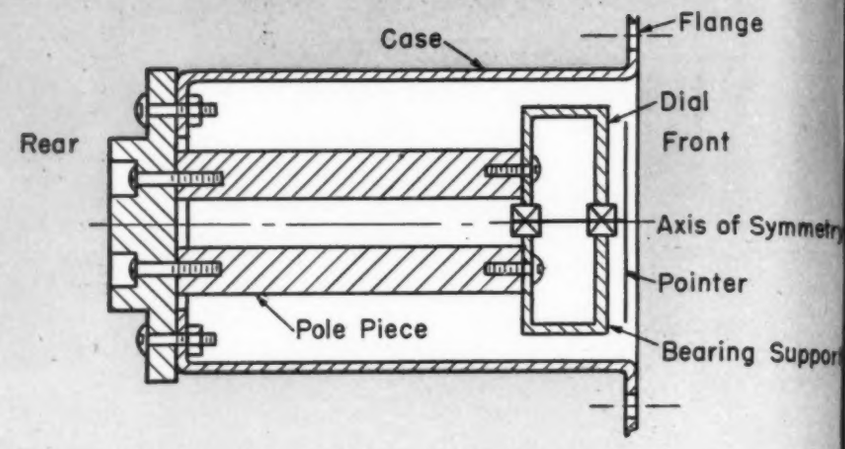


Fig. 4—Cross section of switchboard meter using flexible case for desired shock resistance

of the equipment increases. If the base is unnecessarily heavy, only the mounting bolts receive an excessive force; but, if a component remote from the base is unnecessarily heavy, all structural members between the component and the base must be strengthened to withstand the excessive force.

The most common example of the foregoing principle is encountered in the design of beams. The beam whose cross section is shown in *Fig.* 1*b* is twice as strong as the beam of *Fig.* 1*a* when loaded with an external force directed along the arrow. When loaded only by their inertia forces, however, the beams are of equal strength. The twofold increase in strength of the beam at *b* is exactly compensated by an equal increase in inertia force resulting from a twofold increase in its weight. On the other hand, doubling the depth of the beam, as shown in *Fig.* 1*c*, is efficient because it results in an eightfold increase of the cross-sectional moment of inertia, I, with a fourfold increase of the section modulus, I/c. The inertia force having been only doubled by the added mass, the maximum stress is reduced by 50 per cent.

Most Efficient Distribution of Mass

While some improvement can be attained by proper orientation of beams of rectangular cross section, an even more efficient distribution of mass is embodied in I-beams, channel beams, and other beams that dispose a substantial portion of the beam away from its neutral axis. Mounting feet, supports, levers, and similar members should be ribbed or otherwise stiffened in preference to the use of flat sections. The strength of flat panels under conditions of shock is increased by the provision of welded or formed stiffeners. This is a very effective method because a substantial increase in stiffness is attained with little addition of weight.

One of the most effective illustrations of the practice of obtaining an optimum design through decreased mass and increased strength is found in turbine rotors. This problem is closely related to problems of mechanical shock because the stresses in the rotor result partly from inertia forces. The problem is solved by a method which is applicable to the design of shock-resistant equipment. The volume of material adjacent to the base, or hub, is made large while that adjacent to the periphery is made small. The stress at the hub is thus maintained at a minimum, because a large area is available for supporting the load and because the load is maintained at a minimum by the reduction of mass at the periphery. The optimum design of rotor is shown in *Fig.* 2*b* which indicates, by comparison with *Fig.* 2*a*, the extent of the improvement which may be attained through the reduction of mass at the periphery.

The principle formulated earlier in this article states that the mass remote from the base be reduced as much as possible. A corollary to this principle, which applies when this mass must be great for functional reasons, is to provide a direct independent attachment for supporting the functional mass, thus transmitting the inertia forces directly to the foundation and by-passing other members of the assembly. The corollary may be illustrated by several common examples. A valve of the type used in steam, hydraulic, or compressed air systems should have a direct support independent of the pipes connected to the valve. The pipes are thus relieved from withstanding the inertia force of the valve. The common commercial practice of supporting small electronic components, such as resistors and condensers, by means of the electrical conductors should be avoided whenever practical in equipment required to withstand shock. The provision of independent supports for such components constitutes good design practice.

DECREASE OF STIFFNESS: A second important principle in the design of shock-resistant equipment is to introduce flexibility to some degree into base members, or into structural members which support vital or vulnerable elements of the equipment. This is illustrated schematically by the system shown in *Fig.*

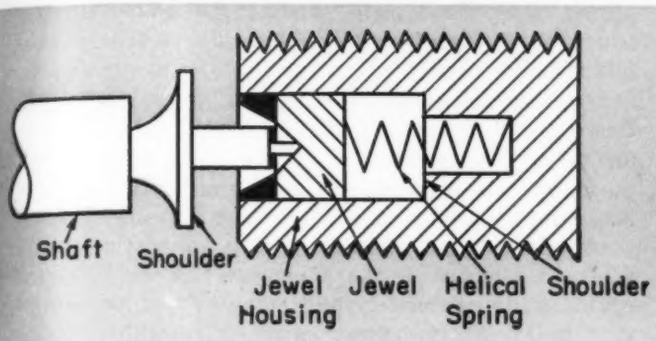


Fig. 5—Above—Section through flexibly-mounted instrument bearing

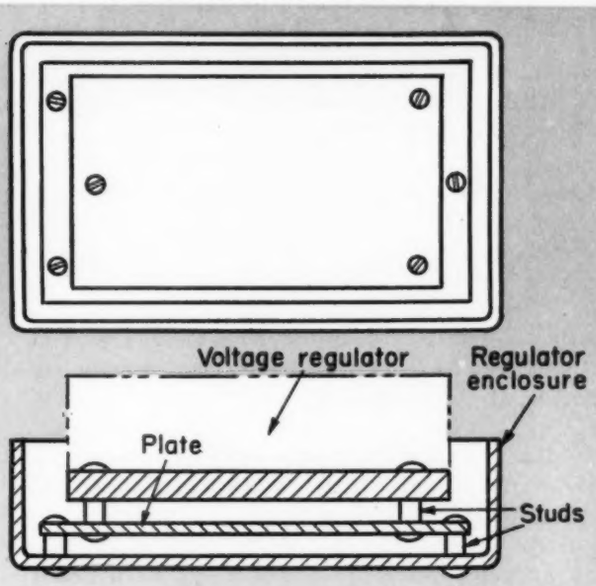


Fig. 6—Right—Flat plate employed to flexibly mount an instrument within an enclosure

3 which comprises two members k_1 and k_2 arranged in tandem to form a cantilever beam for supporting the mass m. In *Fig.* 3*a*, member k_1 is much stiffer than member k_2, and the natural frequency of the system is determined principally by k_2 and m. Since its natural frequency is known, the response of the system to an applied shock may be determined.

If the stiffness of member k_1 is reduced to k_1', as indicated in *Fig.* 3*b*, so that the stiffness k_2 becomes relatively much greater, the natural frequency of the system is determined principally by k_2 and m. It is then evident that the natural frequency of the system shown in *Fig.* 3*b* is lower than that of *Fig.* 3*a*. In general, the forces acting on mass m in *Fig.* 3*b* as a result of shock are substantially lower. In other words, the capacity of the system to withstand shock is increased. Many instances are on record in which shock resistance has been increased by the introduction of flexibility at a strategic location.

A switchboard meter of the moving coil type utilizes the case of the instrument to obtain the desired flexibility. This meter, as illustrated in *Fig.* 4, is of the flush-mounted type which extends rearward from the front of the switchboard, and is attached to the switchboard by means of a flange at the front end of the cylindrical case. The entire mechanism of the meter is supported from the rear end of the case. The flexibility of the front and rear portions of the case, in the direction of the axis of symmetry, provides a relatively low natural frequency in a direction normal to the switchboard panel. The case functions as a cantilever beam in all directions parallel with the panel of the switchboard, and exhibits flexibility, not only because of its own lack of stiffness, but also because of the flexibility of the switchboard panel to which it is secured. The mechanism is thus supported upon a relatively flexible support with respect to shock motions in any conceivable direction.

Another example of the application of this principle is the protection of ball bearings in electric motors by the provision of flexibility in the end bells. An analogy to *Fig.* 3 is evident, wherein the armature corresponds to the mass m, the shaft corresponds to the member k_2, and the end bells correspond to the member k_1. The maximum stress as a result of shock may then be reduced by decreasing the stiffness of the end bells. All members of the system benefit by this reduction, including the ball bearings which are subjected to a smaller force. The decrease in stiffness in the instance of the electric motor may be achieved through the use of pressed-metal end bells. With flexible end bells, there is less chance that the ball bearings will be damaged by shock than with rigid end bells.

Flexibility Increases Shock Resistance

A third example quite similar to the electric motor is found in a small meter whose shaft is supported at the end by a jewel radial and thrust bearing. When such a bearing is rigidly mounted, there is a tendency for the jewel to split and the end of the pointer shaft to become blunted as a result of the large inertia force imposed upon the jewel. By mounting the jewel upon a small helical spring, as illustrated in *Fig.* 5, the system becomes analogous to *Fig.* 3*b*. As a result of flexibility introduced by the helical spring, the maximum inertia force imposed upon the jewel is reduced. The shaft is provided with a shoulder which engages the jewel housing before the jewel bottoms upon the shoulder. Likelihood of damage to the jewel is thus decreased, and the accuracy of the instrument is preserved, by avoiding the blunting of the pointer shaft and eliminating the possibility of damage to the jewel.

The ability of a thin flat plate to flex a large amount without serious deformation has been used to introduce shock resistance in many types of equipment. The particular embodiment illustrated in *Fig.* 6 is employed to protect an instrument that is mounted within an enclosure. The plate is attached to the enclosure by means of three lower studs, while the instrument is attached to the plate by means of three

upper studs which are staggered with respect to the lower studs. The plate thus acts like a diaphragm in permitting movement of the instrument in a direction normal to the plate, and flexes readily to permit movement in a direction parallel to the plate.

OPTIMUM FLEXIBILITY: The examples cited to show the beneficial results attainable with a flexible support should not be interpreted to mean that shock resistance is always increased by the mere expedient of increasing the structural flexibility of the equipment. Whereas too little flexibility may result in excessive inertia forces, too much flexibility may result in damage to the flexible member or to associated members. Optimum flexibility lies between these extremes.

The degree of flexibility required depends upon the characteristics of the structure being considered. The need for flexibility may be shown by failure of the equipment to withstand shock, or may be indicated by an analysis which reveals the lack of a flexible support for a vulnerable, rigid member. In either case, an increase in flexibility is called for. The next step is to determine, from a study of the equipment, the member whose stiffness should be decreased. In general, optimum conditions embody the greatest acceptable stiffness. If the stiffness is too low, the natural frequencies are low and the following detrimental conditions may exist:

1. The deflections of structural members are great, and special attention should be directed to insuring that rupture or excessive deformation does not occur
2. One component may impact against another if supported upon structures which lack sufficient stiffness. In introducing structural flexibility, adequate clearances between components should be provided.

The benefits derived from the use of a flexible member may be decreased rather than enhanced if too many flexible members are used. An optimum design comprises a rigid, compact assembly attached to the supporting base by means of a relatively flexible member capable of withstanding an appreciable deflection. All elements of the supported assembly thus receive the same acceleration. If certain elements of the assembly have the same natural frequency as the flexible supporting member, a transient condition resembling resonance may occur. The shock excites free vibration of the supporting member. An element of the supported assembly, if resonant at approximately the same frequency, would then be excited to vibrate with an amplitude which increases at each cycle. A more rigid element, although subjected to this vibration, would not be excited into resonance. It follows, therefore, that the benefits attainable by the use of a flexible member are not fully realized unless all elements of the assembly supported by such members are made substantially more rigid than this flexible member.

Another limitation on the degree of flexibility which can be tolerated is dictated by the requirement that the parts of the equipment not be resonant with any steady vibration to which the equipment is subjected. It should be remembered that this steady vibration is continuous and could result in fatigue failure of the lightly damped members of the equipment if a resonant condition should result.

MAXIMUM ENERGY STORAGE: The preceding explains the advantages which result from flexibility of structural members, and points out certain limitations on the degree of flexibility. Flexibility infers a relatively low natural frequency. A member of low natural frequency experiences a large deflection, and must be structurally capable of withstanding such a deflection. The deflection of an elastic member is an indication that it has stored energy. Structural members should therefore be designed to store as much energy as possible before the metal in the most severely stressed region reaches the elastic limit. This requires, in effect, that the stress be maintained as uniform as possible throughout the

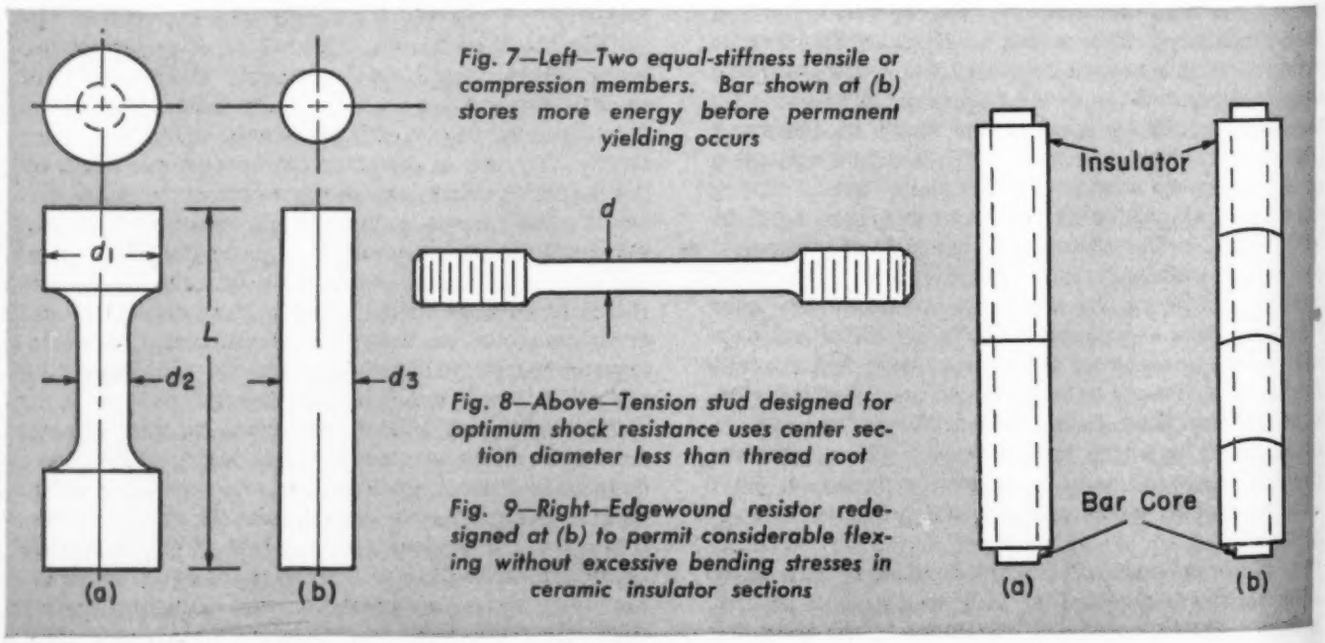


Fig. 7—Left—Two equal-stiffness tensile or compression members. Bar shown at (b) stores more energy before permanent yielding occurs

Fig. 8—Above—Tension stud designed for optimum shock resistance uses center section diameter less than thread root

Fig. 9—Right—Edgewound resistor redesigned at (b) to permit considerable flexing without excessive bending stresses in ceramic insulator sections

member. The basic principle of design may now be stated: All structural members should be designed, insofar as possible, to experience the same stress throughout in order to insure the greatest possible energy storage before yielding occurs in any part of the structure.

The principle of maximum energy storage may be illustrated by considering two members, as shown in *Fig. 7*, subjected to pure tensile or compressive stress. The two members are made of the same material, and have equal length and stiffness. The diameters therefore must be in accordance with the relation, $d_1 > d_3 > d_2$. Since the stiffnesses of the two members are equal, their maximum total deflections when subjected to shock are equal. It now becomes of interest to examine the unit strain and unit stress. In the member shown in *Fig. 7a*, the strain is limited largely to the small portion whose diameter is d_2. In the member shown at *b*, however, the strain is distributed equally over the length. The unit strain, and therefore the stress, is lower in member *b* than in member *a* for the same over-all deflection. A greater over-all elastic deformation thus becomes possible when the section is substantially uniform from end to end, and a greater amount of energy may be stored before permanent yielding occurs.

Uniform Section Permits Greater Deformation

This principle is applied to good effect in the design of long bolts and studs loaded in tension by shock forces. A stud is shown in *Fig. 8*, in which the diameter, *d*, of the central portion is made slightly less than the diameter at the root of the thread. The reason for this is that stress concentration develops at a notch, such as a thread, and the actual maximum stress is somewhat greater than would be inferred from the root diameter. This should be taken into account in arriving at a diameter *d*. If this diameter is properly selected, the actual stress in the central portion will be slightly greater than the stress at the root of the thread. The member then embodies optimum design from the standpoint of shock resistance.

An ideal design of member intended to be subjected to a bending moment would have a uniform stress throughout the entire area of the cross section. It has been pointed out that I-beams and channels are preferred to solid beams because they approach more closely to this ideal. That reasoning was applied to the design of a beam intended to support its own weight under conditions of shock. A similar conclusion is reached in designing a cross section to insure maximum energy storage. The most efficient arrangement would have all material at an equal distance from the neutral axis. This is not practicable, however, because it provides no constraints for this material. It can be approached, for example, in the commercial channel loaded parallel with the web.

Equipment frequently can be protected from shock by designing the mounting bolts with low strength and low stiffness. This often represents the only means by which flexibility can be attained, as in equipment having a heavy cast base. The possibility

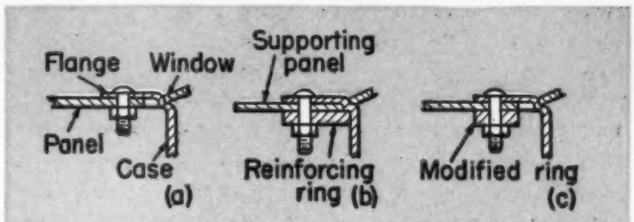
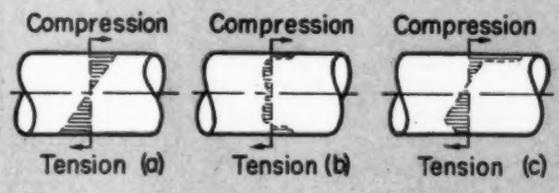


Fig. 10—Above—Support for glass instrument window redesigned unsuccessfully with rigid reinforcing ring as at (b) and successfully with modified ring (c)

Fig. 11—Below—Effect of residual compressive stress upon member subjected to bending



should always be explored, however, of employing base members whose stiffness is equal to or less than that of the mounting bolts. A member of substantial size, such as a mounting bracket or a structural member of a large switchboard, presents much greater potential energy storage capacity than a bolt.

AVOIDANCE OF STRESS CONCENTRATION: The next important design principle is that stress concentration should be avoided to the greatest extent possible. This could perhaps be considered a special case of the preceding principle, but is treated separately here because it deals with localized conditions whereas the preceding principle treats structural members from an over-all viewpoint. If local yielding or rupture takes place, the structure as a whole is prevented from capitalizing its potentialities as an energy-storing medium. This was considered in detail in connection with the preceding principle.

AVOIDANCE OF PARALLEL CONNECTION OF FLEXIBLE AND RIGID MEMBERS: The next basic principle applies to the design of composite structures comprising both flexible and rigid members. Rigid elements should not be arranged in parallel with flexible elements, unless the rigid elements have adequate strength to constrain the flexible elements against the forces generated by shock motions. Flexible elements often serve a valuable function of reducing the acceleration experienced by components of the equipment, and this function should not be unnecessarily impeded by the application of rigid constraints. Several examples will illustrate various aspects of this condition.

The first example refers to the edgewound resistor shown in *Fig. 9*, wherein the brittle element is the rectangular ceramic insulator and the flexible element is the steel bar core embedded in the ceramic sections. The original design embodied long, square-ended ceramic sections as shown in *Fig. 9a*. These sections would chip off near the ends and split lengthwise as a result of flexure of the relatively flexible steel core. The new design embodies shorter ceramic

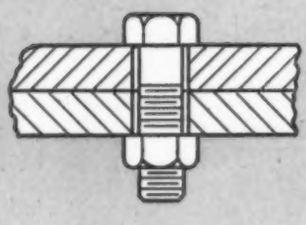


Fig. 12—Above—Unsatisfactory method of fastening two members with bolts in clearance holes

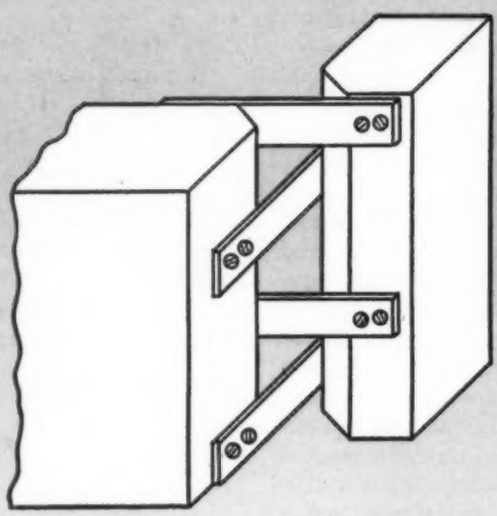


Fig. 13—Right — Elastic hinge substitute for knife edge, eliminating possibility of shock impact between knife edge and seat

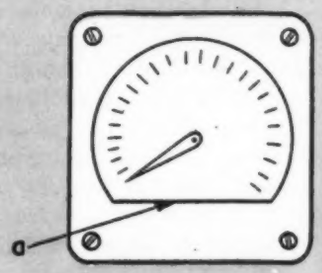


Fig. 14—Above — Flat section on front of meter case for preventing ejection of mechanism from case if holding screws fail

sections with rounded ends as shown in *Fig.* 9*b*. The knee action thus provided permits the resistor to undergo considerable flexing without imposing substantial bending stresses on the ceramic sections. The likelihood of shock failure is thus materially reduced. In this instance, shock resistance was obtained by making the rigid element capable of partaking of the deflection of the flexible element. In general, shock resistance tends to be increased by a change which brings the stiffnesses of the two elements more nearly into equivalence.

Series Arrangement Eliminates Relative Motion

It often is advisable to avoid all parallel connections by cascading the elements or, in other words, by employing only series connections. This is illustrated in the cross section of the meter, *Fig.* 4. This meter is mounted substantially in the plane of its face by means of a peripheral flange extending outwardly from the cylindrical case. The pole piece is attached to the rear end of the case. The front end of the pole piece carries the bearing support to which the dial, in turn, is attached. All vital elements are thus cascaded. It is readily visualized that, if the dial were attached to the case, relative motion would result between the dial and the pointer when the pole piece deflects relative to the front of the case. Possibility of damage resulting from this relative motion is eliminated by cascading the elements, thereby eliminating the relative motion.

An interesting instance of the failure of a rigid member as a result of deformation of a flexible member is found in a small instrument having a glass window. The arrangement, as shown in *Fig.* 10*a*, embodies a glass window soldered to the cylindrical case of the instrument adjacent to the peripheral mounting flange. The instrument is mounted by securing the flange to a supporting panel. During shock, the mounting flange experienced substantial deformation and the glass, being unable to withstand such deformation, failed. A reinforcing ring as shown in *Fig.* 10*b* was then added to reduce the deformation experienced by the mounting flange. The result was continued failure of the glass, not because of deformation of the flange, but now because of the large force transmitted by the rigid reinforcing ring. A modified reinforcing ring as shown in *Fig.* 10*c* serves to prevent excessive deformation of the flange while leaving adequate flexibility between the glass and supporting panel to prevent transmission of the destructive large force.

RESIDUAL COMPRESSIVE STRESS: Another basic principle, applicable particularly to members subjected to a bending moment, is to maintain the outer fibers of the member under a residual compressive stress. Cracks leading to failure of a member subjected to bending usually start at the surface which has a tensile stress. The crack does not start if the surface stress is compressive. A residual compressive stress serves to reduce the resultant value of any superimposed tensile stress.

The stress pattern in a member subjected to bending is shown in *Fig.* 11*a*. If the member, prior to being stressed, is subjected to cold rolling, shot peening, or nitriding, the surface fibers of the member receive a compressive stress. In order to attain an equilibrium condition, the core of the region has a tensile stress, as shown by the residual stress pattern in *Fig.* 11*b*. When the member having the residual stress of *Fig.* 11*b* experiences the bending stress of *Fig.* 11*a*, the two stresses are added to produce the resultant stress shown in *Fig.* 11*c*. It is thus evident that the maximum tensile stress in bending is reduced and the maximum compressive stress is increased. Since a crack starts in a region of tensile stress, the strength may be considered to be increased.

The same principle is employed in a somewhat different manner to increase the strength of brittle materials, which are characteristically weak in tension and strong in compression. Porcelain, for example, is an invaluable ceramic for use in electric resistors because of its electric properties. The material, however, has a very low tensile strength. This disadvantage is largely overcome by inserting a steel

bolt through the central hole of the porcelain bushing. The bolt is tightened and the porcelain is stressed in compression. Any subsequent loading which tends to apply a bending moment must overcome the residual compressive stress in the porcelain before the tensile stress becomes of appreciable magnitude. The strength of the bushing is thus increased.

LIMITATIONS OF FRICTION AND GRAVITY FORCES: It may be stated as a general rule that gravity and friction forces should not be relied upon to position members whose positive positioning is essential to the operation of the equipment. The inertia forces developed during shock frequently are greater than the designer envisions, and friction forces which would be adquate under static conditions may not be satisfactory under shock. The nature of the trouble which develops, and the remedies therefor, will become apparent from the following examples.

Positioning By Gravity Is Inadequate

The forces of gravity should never be relied upon to maintain an equipment or component positioned on a ship, vehicle or aircraft. Members resting in receptables, such as batteries in battery racks and tools on tool racks, should always be held in position by clamps or other suitable means. A body suspended on open-end helical springs is not satisfactorily secured because it may experience motion of such large amplitude that the springs are relieved of tension and become disconnected. Such springs should be so attached that they cannot be accidentally disconnected.

Two members, attached by bolts in clearance holes as shown in *Fig.* 12, and positioned relative to each other only by the friction at the interface, may be moved out of alignment by the shock. This can occur as a result of permanent elongation of the bolt and release of the friction forces at the interface. High speed motion pictures show instances where the bolt elongates elastically and the bolted members shift position during the momentary release of the friction. Bolted joints are also known to have become loose as a result of the nut backing off while the bolt is momentarily elongated elastically.

Elongated bolt holes are thus undesirable because they permit excessive misalignment. The same objection applies to open slots, which are more objectionable because of the possibility of disengagement. Acceptable designs employ dowel pins or keys in addition to bolts, or utilize body bound bolts; i.e., bolts which fit snugly through the holes and thereby prevent misalignment. Members which require adjustment during or after final assembly may be provided with dowel pins inserted in holes drilled through the two members after the final position has been accurately determined.

It is preferable not to secure machine elements, such as gears and cranks, to shafts by means of friction forces alone. Press or shrink fits, which are commonly used commercially, are frequently unsuitable for shock-resistant applications because the friction created thereby may not be adequate to locate the element securely. Such elements should be pinned or keyed to the shaft wherever possible in order to maintain positive alignment. There is also need to prevent misalignment parallel with the shaft.

Clearances and backlash should be eliminated wherever possible from mechanisms used in shock-resistant equipment. In this respect, knife-edge supports are particularly objectionable because it is difficult to positively maintain the knife edge in contact with the seat without applying a large restraining force which unduly sacrifices the accuracy of the support. Impacts between the knife edge and its seat are thus likely to occur with consequent danger of damage thereto. Further difficulty arises from the tendency of the knife to slide lengthwise on the seat. An effective replacement for a knife edge is a journal bearing, where some friction can be tolerated, or an elastic hinge as illustrated in *Fig.* 13, where friction is intolerable but an elastic moment acceptable.

LIMITING MEANS FOR FLEXIBLE MEMBERS: A member required to remain permanently undeformed may be provided with means to limit its deflection so that the stress does not exceed the yield stress. It may sometimes be impossible, for reasons peculiar to the equipment, to attain the necessary strength inherent in the member. Where a particularly vital member is involved, it is good foresight to provide limiting means as insurance against the very occasional shock of extreme severity which would otherwise cause damage to such a member.

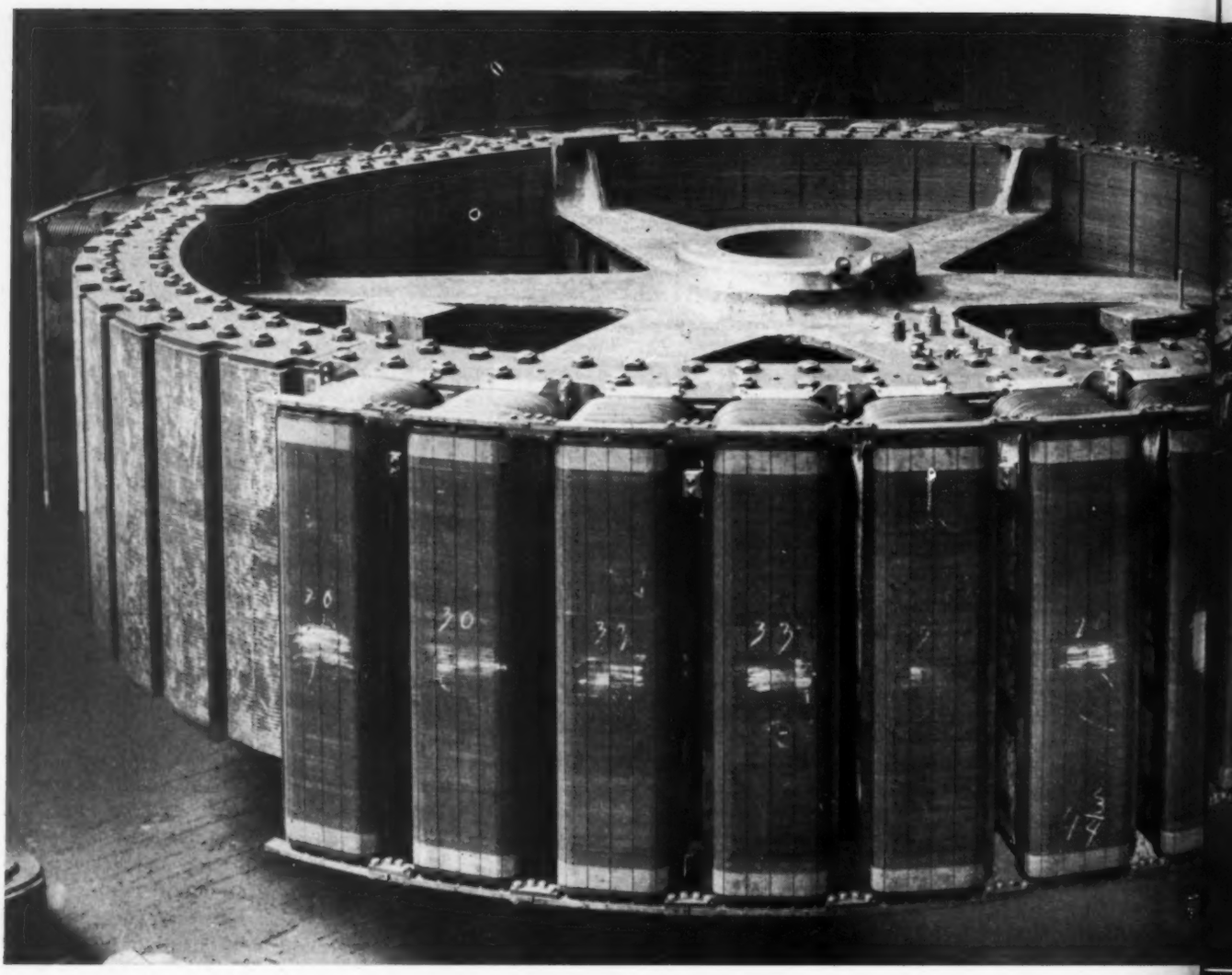
CAPTIVE RETAINING MEANS: In the design of equipment for shock resistance, care should be exercised to prevent secondary damage resulting from a primary failure. The primary failure, in the instance referred to, usually takes the form of rupture of a securing means. An auxiliary retaining means should be provided to maintain the equipment or component captive, and prevent its becoming a projectile. Such a projectile is hazardous for several reasons:

1. It may cause mechanical destruction of adjacent equipment in its path
2. It may fall across live electrical conductors or moving parts, causing damage to or immobilization of other equipment
3. It may cause injury to personnel.

Referring to the meter shown in *Fig.* 4, if the screws which secure the pole piece to the rear of the case should fail under shock, the entire inner mechanism may be projected through the instrument window unless retaining means is provided. In order to prevent this eventuality, the shape of the window is made substantially round but with a lower flat portion, *a,* as shown in *Fig.* 14. The flat portion of the metal cover forms a barrier to prevent ejection of the mechanism from the case, with possible danger to personnel working in front of the switchboard.

Shock mounts should be designed so that the equipment remains captive, even though the resilient element ruptures. It is satisfactory to use, in conjunction with rubber shock mounts or as a part thereof, an assembly of interlocking metal members which positively retain the mounted equipment captive.

The final section of this two-part series, to appear in a subsequent issue, outlines basic principles of design to prevent maloperation of equipment subjected to shock.



Designing a Large Weldment

By L. G. Hauser
Westinghouse Electric Corp.
Buffalo, N. Y.

A WATERWHEEL generator is the heart of large, present-day hydroelectric power stations. An up-to-date version of the old fashioned waterwheel used years ago, modern generators have generally been designed with all structural parts of welded construction except the rotor spider, *Fig.* 1. This part has been of cast-steel as shown in *Fig.* 2, until recently it was decided to investigate the possibilities of welded design for this critical component.

Rim of the generator rotor is made of laminated electrical steel. Stacked around the spider to the proper height, these laminations are heated to a predetermined temperature by electric space heaters. This, of course, causes the rim to expand and at this temperature the laminations are bolted solidly together by the double row of bolts seen in *Fig.* 1. On cooling the rim contracts around the spider and creates a compression loading.

There is nothing new in shrinking a rim onto a wheel except in this case the heating and shrinking are controlled to give a stress of about three million pounds per leg. When the rotor is at operating speed, centrifugal force is about three million pounds per leg and thus the rim is literally floating on the spider because the compression force caused by the shrinking is counteracted by the centrifugal force of speed.

Based on a paper presented at the Eleventh Annual Ohio State Welding Engineering Conference in Columbus, Ohio, April 14-15, 1950.

Cast-steel spiders are usually made from 0.35-carbon steel. From a design standpoint this cast steel has a yield point of 35,000 psi. Since physical dimensions of a fabricated spider would be essentially the same as for the cast-steel spider, *Fig.* 2, rolled 2-inch SAE 1015 plate was employed for the legs. This plate has a yield point of 30,000 psi.

Theoretically, the fabricated spider would weigh more than the cast-steel design, but this is not the case in actual practice because it is necessary to make the cast flanges thicker than the design calls for to eliminate warpage in the spider legs when the casting is cooling. Actually, the weight of the fabricated steel spider is approximately the same as that of the cast-steel job.

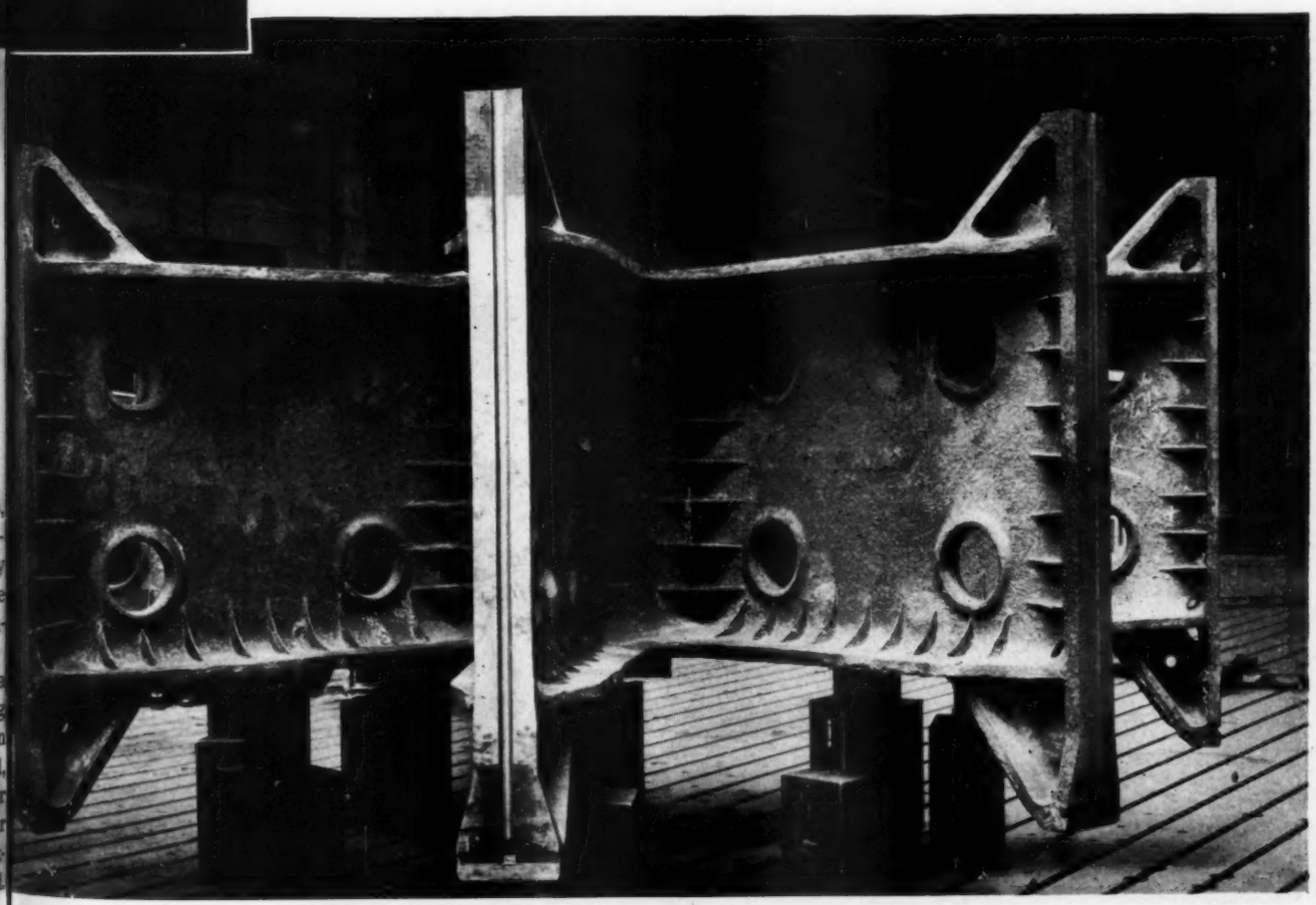
It is not feasible to fabricate the heavy steel hub from rolled plate. A cheaper and better method is to make the hub from an SAE 1035 steel forging. As can be seen from *Fig.* 3, the side or flange plates are cut from one piece of plate. This gives two sprocket-shape pieces which must be fastened to the hub. This joint is the most critical in the whole spider. Rather than make a tee-joint at the hub, use of a 2-inch nose projecting from the hub permits fastening the flange plates with a double-U butt joint. This double-U butt joint enables a better quality weld to be made at this point.

WELDING: The hub and the flange plates are pre-heated to 300 F and kept at this temperature during the whole welding operation. Three-sixteenth inch diameter 6011 electrode was used with a-c welding current. After both flange plates had been completely welded to the hub the spider was placed in an annealing furnace and brought up to 1150 F. It was cooled at the rate of 100 F per hour until 300 F was reached. At this point the welds were x-rayed for quality.

The next step was to weld the six web plates in place. The first welds to be made were the fillet welds attaching the web plates to the hub. These welds were made in the vertical up position using 6011 electrode. The fillet welds attaching the web plates to the flange plates were made in the horizontal fillet position using 6020 electrode,

Fig. 1—Left — Waterwheel generator rotor partially constructed using a cast-steel center spider. Redesign for welding reduced cost

Fig. 2—Below—Cast-steel center spider used for generator rotor. Outer flanges are increased in thickness to resist warpage



with one on each side of the web at each flange. After this operation was completed on all six legs the spider was again placed in the annealing furnace. The same annealing procedure was used. After annealing, the web welds were Magnafluxed for defects.

The plate assemblies which appear on the end of each leg were made as subassemblies. The subassemblies were welded to the spider legs out of position using 6011 electrodes. The entire spider was again annealed and all welds in the spider were Magnafluxed for defects.

COST ANALYSIS: There is a decided savings realized by the change from cast to fabricated steel. This is indicated, for example, by representative costs of equivalent spiders. The rough casting as delivered from the foundry costs $17,406. Grinding and Magnafluxing the casting cost $4046, including welding of defects. A cast-steel spider thus costs $21,452 in the unfinished condition. Machining costs which include removing of excess stock, turning, boring and facing the complete spider amount to $6070. This brings the total cost of a finished cast-steel spider into the neghborhood of $27,500.

Finish Machining Costs Lower

The forged hub used in the fabricated steel spider costs $5514, steel plate $3800, making a material cost of $9314. Machining and burning preparatory to welding costs $1943. The welding, annealing, assembly and inspection of the complete spider costs $8850, making the fabricated steel spider approximately $20,107 in the unfinished condition. Finish machining which includes turning, boring and facing costs $5121, resulting in a total cost of a finished fabricated steel spider approximately $25,200.

It will be seen that there is a large saving in the finish machining cost of the fabricated steel spider. This is due to a well planned and closely supervised welding procedure which keeps warpage to a minimum. As a result, the rough dimensions could be kept closer to the finish dimensions to reduce the amount of excess stock necessary.

Greater Design Leeway

SUMMARY: In order for a fabricated part to replace a cast part, the welded part must equal or better the cast part in several categories:

1. *Quality*: In this case the quality of the fabricated steel spider is equal to or better than the quality of the cast steel spider
2. *Cost*: The finished fabricated steel spider represents a saving of approximately ten per cent of the cost of the cast steel spider
3. *Weight*: The finished weight of the two spiders is approximately the same
4. *Cost of Design Changes*: Cost of design change for the fabricated spider would be limited to the engineering and drawing costs. In the case of the cast-steel spider there would be the additional cost of a pattern change
5. *Production Control*: The fabricated steel spider can be manufactured from raw material to finished product in our own shops. This gives complete control of production and quality.

Since our shops cannot handle castings of such size it is necessary to purchase them. Fabrication thus eliminates dependence on outside sources for quality and deliveries as well as a substantial portion of the original cost.

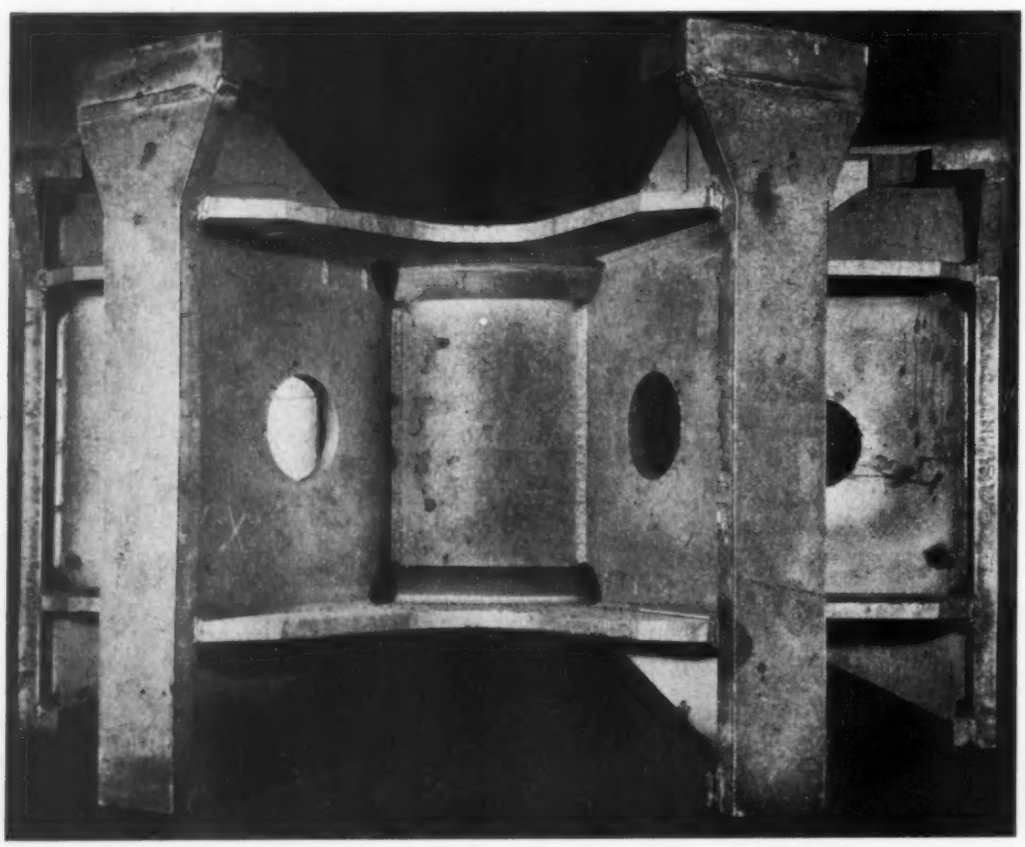


Fig. 3—Left—All welded SAE 1015 steel rotor spider to replace that of Fig. 2

Stepped Film Bearings

By Frank R. Archibald
School of Engineering
Princeton University
Princeton, N. J.

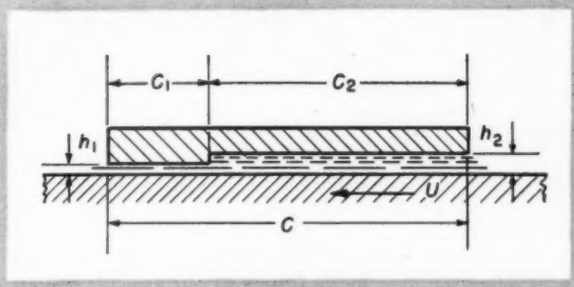


Fig. 1—Parallel-film step bearing discussed in article, showing stationary stepped plate at top, moving bearing surface at bottom

SUCCESS of the inclined, flat plate slipper bearing has resulted in a virtual neglect of other bearing design possibilities. In a little known paper by Lord Rayleigh[1], dated 1918, the problem of the slider bearing with no side leakage is examined in great detail. Rayleigh showed that the film shape for greatest load capacity is a stepped parallel form as shown in *Fig.* 1.

The author has considered the stepped film shape when side leakage is taken into account and found it to compare very favorably with the common inclined plane bearing.[2] When side leakage is neglected, the maximum load per unit width supported by the stepped slider, W_{max}, is

$$W_{max} = \frac{0.206\,{}_{\mu}Uc^2}{h_1{}^2}$$

where μ is the lubricant viscosity, U is the sliding velocity and c and h_1 are dimensions shown in *Fig.* 1. The proportions in this case are $c_2 = 2.549c_1$ and $h_2 = 1.866h_1$. An inclined flat plate having the same constraints will support a maximum load of

$$W_{max} = \frac{0.160\,{}_{\mu}Uc^2}{h_1{}^2}$$

The stepped arrangement under this condition is about 29 per cent more effective. This advantage is not held when side leakage is considered. For a square bearing the stepped shape is only about 3 per cent more effective than the inclined flat plate.

When side leakage is considered, the foregoing formulas require considerable modification. They can be written

$$W = \frac{K_1\,{}_{\mu}Ubc^2}{h_1{}^2}$$

where b is the width and K_1 is a coefficient which de-

[1] References listed at end of article.

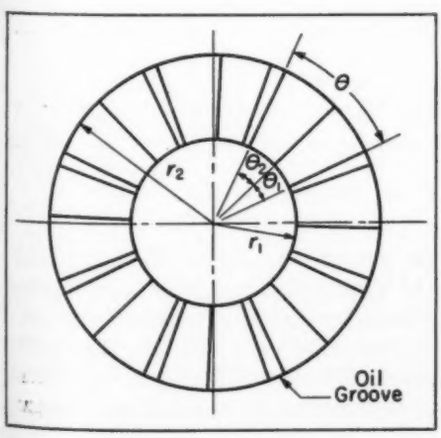


Fig. 2—Left — Arrangement of sector pads for thrust bearing using stepped construction

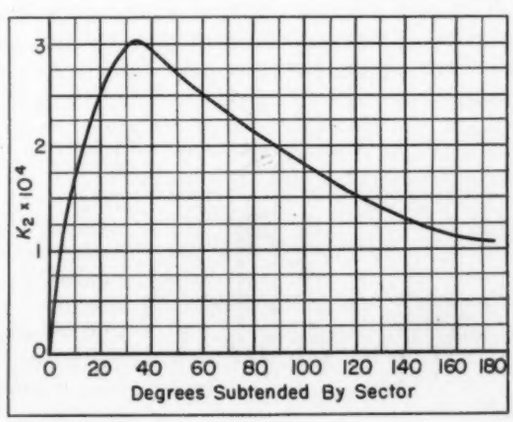


Fig. 3 — Right — Curve for determining K_2 coefficient for use in load formula

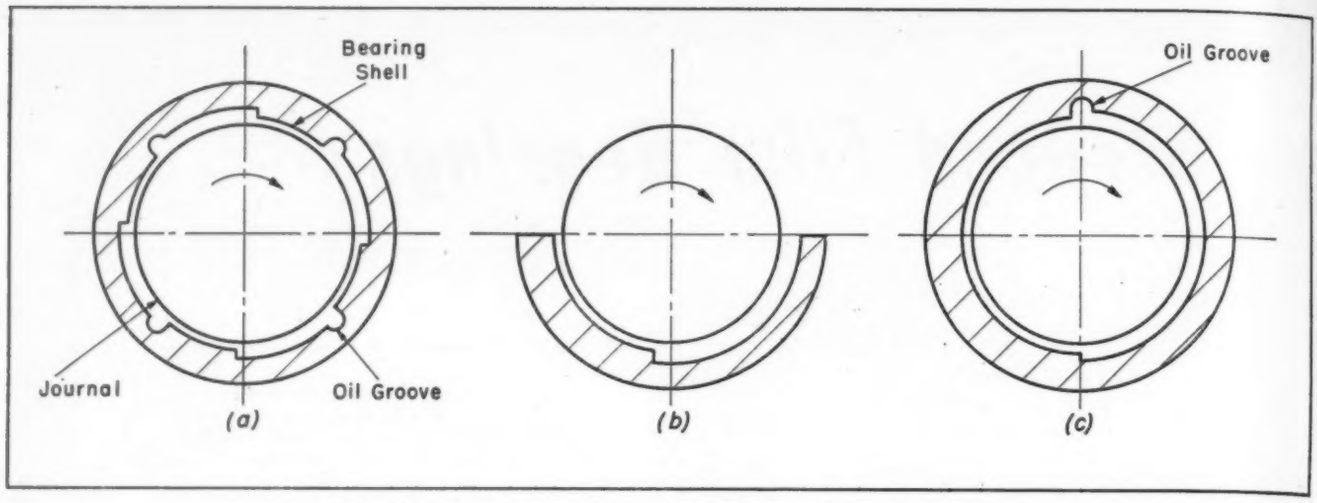


Fig. 4—Application of parallel step design to journal bearings. Arrangements shown at (b) and (c) are suitable for loading in one direction only

pends on the width-length ratio. Values of K_1 for the stepped bearing for various width-length ratios are given in TABLE 1.

The best proportions for a bearing of finite width are somewhat different from those where side leakage is neglected. For a square bearing the best proportions are $c_2 = 1.2\ c_1$, $h_2 = 1.7\ h_1$. But the load capacity is not greatly affected by changes in these values over a wide range. The values for TABLE 1 are all computed using $c_2 = 1.2\ c_1$ and $h_2 = 1.7\ h_1$.

The usual arrangement for a flat bearing is in the form of a sector pad for a thrust bearing as shown in *Fig.* 2. In this case the load formula is

$$W = \frac{K_2\ N r_1^4}{h_1^2}$$

where N is the speed in revolutions per minute, θ is the total sector angle in degrees and r_1 is the inside radius of the bearing sectors. Values of the coefficient K_2 are given in the curve of *Fig.* 3, with values based on a ratio $r_2/r_1 = 2$. The proportions of the steps are $\theta_2 = 1.2\ \theta_1$ and $h_2 = 1.7\ h_1$.

Journal Bearing Applications

By use of *Fig.* 3 it is possible to find the number of pads for the greatest load if an oil groove size is selected. For example, if 5 degrees is taken for the oil groove, it turns out that 8 pads give greatest load capacity. Where the thrust capacity desired is small, the bearing can be made more simply by using fewer pads.

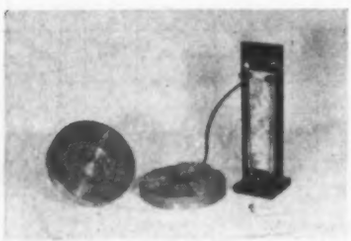


Fig. 5—Air-lubricated model of parallel step bearing uses 0.00005-inch step height, develops 3 inches mercury pressure at center of bearing pads

The possibility of applying the stepped film to journal bearings is interesting. *Fig.* 4 shows three possible arrangements. *Fig.* 4*a* is perhaps the most interesting. It would be a stable arrangement and has possibilities for a grinding machine spindle bearing, for instance. *Figs.* 4*b* and *c* are only suitable for loading in one direction. The author has considered the side leakage problem for these bearings but the analysis is long and has not been reduced to a readily workable form.

TABLE 1—Width-Length Ratio Coefficients

$\frac{b}{c}$	K_1	$\frac{b}{c}$	K_1
¼	0.0001842	1	0.07251
½	0.01350	1½	0.1566
¾	0.03998	2	0.2480

This stepped film arrangement, either as a thrust or journal bearing, should find many industrial applications. For a thrust surface, the shape is easily produced since it can be made on a surface grinder. Considerable self-alignment could be provided if the thrust element were set in an oil-resisting rubber. An air-lubricated model of a parallel step thrust bearing has been built for demonstration purposes, as shown in *Fig.* 5. The step height (i.e., $h_2 - h_1$) is about 0.00005-inch. When running, pressure about 3 inches of mercury is obtained at the center of one of the pads.

[1] "Notes on the Theory of Lubrication", *Philosophical Magazine*, Vol. 35, 1918, Pages 1-12.

[2] "A Simple Hydrodynamic Thrust Bearing," ASME *Trans.*, Vol. 72, No. 4.

THE aluminum industry produces about 1.25 billion pounds of pure aluminum yearly, requiring the use of 12.5 billion kw hours of electricity. Aluminum has more than 4000 uses and is a basic raw material for more than 17,000 businesses in the United States, employing approximately one million persons.

Nomographic Design of Helical Springs

By John H. Keyes
Design Engineer
Dempsey Pump Co.
Tulsa, Okla.

DESIGNERS frequently feel the need of a quick and simple means to determine the specifications of springs to fit their requirements. The nomogram on the following page, especially prepared for this purpose, will satisfy most needs although it may need to be supplemented in certain critical applications.

Most designs call for springs that can be classified roughly in three groups: (1) those that are limited by available space, (2) those that must meet certain performance data and (3) those that must meet both these requirements. The chart presented in this article provides a means for determining the dimensions of a steel helical spring to meet a given specification of load and travel, and the behavior of a spring to fit within a given space.

The nomogram is based on the standard formulas for the design of springs:

$$y = \frac{8PND^3}{Gd^4}$$

$$s = \frac{8PKD}{\pi d^3}$$

$$K = \frac{4c - 1}{4c - 4} + \frac{0.615}{c}$$

Nomenclature

- c = Spring index
  $= D/d$
- D = Pitch diameter of coil, inches
- d = Diameter of wire, inches
- G = Shear modulus, psi (11,000,000 for steel)
- H = Free height, inches
- h = Solid height, inches
- K = Stress correction (Wahl) factor for curvature
- N = Number of active coils
- P = Spring load, pounds
- s = Shear stress, psi
- y = Total deflection, inches
- y/NP = Deflection per coil per pound of load
- P/y = Spring rate
- s/P = Stress in wire per pound of load

EXAMPLE: Determine the dimensions of a spring which will fit loosely in a 1-inch hole, have a spring rate of 20 pounds per inch and develop a stress of 125,000 psi at maximum compression.

By inspection and trial select values for D and d that give an outside diameter of about 0.950 inch and a favorable spring index. Index Line 1 is drawn through a set of values meeting these requirements: $D = 0.875$, $d = 0.105$, $c = 8.5$, and $y/NP = 0.004$.

Index Line 1 gives also an intersection with reference scale A. Through this intersection and the value for K corresponding to the indicated value of c, draw Index Line 3, finding $s/P = 2235$.

Through this point and that for 125,000-psi stress, draw Index Line 2, finding, as a maximum, $P = 56$ pounds.

With this point and that for the given spring rate, $P/y = 20$, draw Index Line 7, finding $y = 2.8$ inches, total travel.

This value of y, together with $y/NP = 0.004$, found by Index Line 1, locate Index Line 5 to give an intersection with reference scale B.

From this point on B, and $P = 56$ found on Index Line 2, draw Index Line 4, finding $N = 12.6$ active coils.

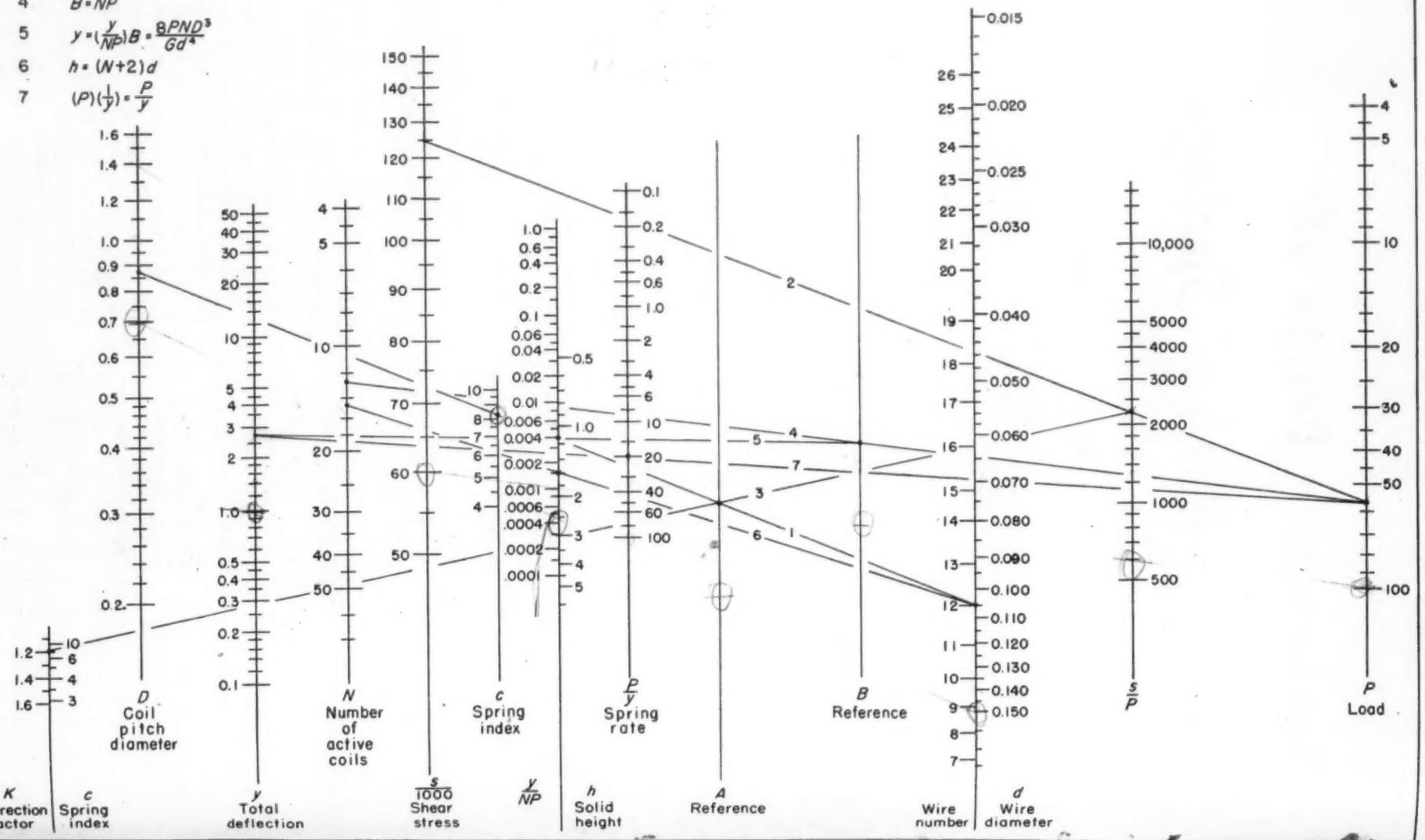
If it is assumed that the spring will have two inactive coils, draw Index Line 6 from $N = 14.6$ to the point, $d = 0.105$, found by Index Line 1, finding $h = 1.53$ inches, solid height.

The data show that: solid height, $h = 1.53$, spring travel, $y = 2.80$; and their sum, free height, $H = 4.33$.

Thus a complete picture of the spring is given, sufficiently accurate for the designer to plan the accompanying parts of his device to accommodate it. A similar procedure can be followed to solve other types of problems. By starting with the known or required specifications, whether of dimension or of behavior, and by drawing the index lines determined by them, the designer can follow line by line until he finds a value for each characteristic. In many cases, as in the problem discussed, several solutions can be found. The designer must rely on his best judgment, often with no help from the nomogram, to select the most suitable.

Chart for Designing Helical Springs

Index line*	Formula
1	$\frac{y}{NP} = \frac{8D^3}{Gd^4}$ $\quad A = \frac{8D}{\pi d^3}$
2	$(s)(\frac{1}{P}) = \frac{s}{P}$
3	$AK = \frac{8DK}{\pi d^3} = \frac{s}{P}$
4	$B = NP$
5	$y = (\frac{y}{NP})B = \frac{8PND^3}{Gd^4}$
6	$h = (N+2)d$
7	$(P)(\frac{1}{y}) = \frac{P}{y}$



DESIGN ABSTRACTS

Gas Turbine Truck

By W. M. Brown
Kenworth Motor Truck Corp.
Seattle, Wash.

A GAS turbine is a heat engine which utilizes the expansion from the combustion of fuel and air in a combustion chamber by transforming that energy directly into either thrust or shaft power. The expanding gases are directed against a turbine wheel driving a rotary compressor which crams an excess of air into the combustion chamber. The products of combustion after leaving the compressor wheel may be directed through a nozzle, producing jet thrust. Or, as in the case of the Boeing Truck Turbine, they may be directed against a secondary turbine wheel, the shaft of which, driving through reduction gears, produces shaft power.

The model 502 shaft-power turbine here discussed was developed by the Boeing Airplane Co. under the sponsorship of the Navy Dept., Bureau of Ships. For test in ground vehicle propulsion, the unit was installed in a Kenworth truck chassis. Some potentials of this type of application have been revealed by preliminary evidence.

Though the gas turbine is far from a perfect heat engine, its basic principle is that of the conversion of the products of the combustion of fuel directly to rotary shaft power with the absence of any reciprocating motions in producing either thrust or shaft power. The advantage of obtaining rotary power without reciprocating motion has long been recognized, but it has been only within recent years that techniques have been understood and materials available to accomplish this.

The entering air is compressed by a centrifugal blower and discharged past fuel injection nozzles in cylindrical combustion chambers where continuous combustion takes place. The products of combustion of the two chambers are directed through a primary turbine where two thirds of the energy of the gases is extracted in turning the compressor shaft. The remainder of the gas is led through a secondary turbine where shaft power is produced. The compressor shaft turns at 36,000 rpm at full power; the secondary turbine turns at 22,650 rpm and drives through 9.06 to 1 reduction gearing, resulting in an output shaft speed of 2500 rpm at rated power and speed.

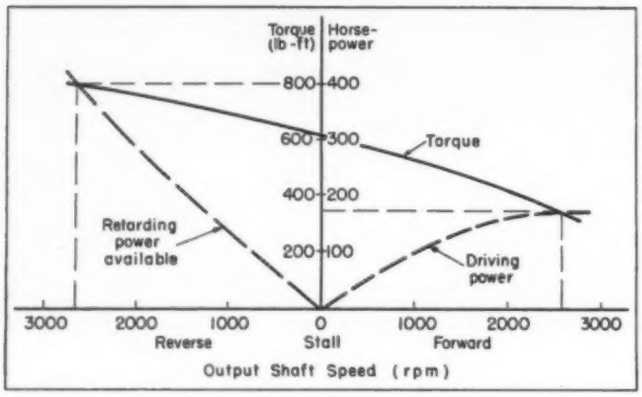
Advantages of the gas turbine are as follows:

1. Light weight. The complete unit weighs slightly more than 1 pound per horsepower
2. Small installation space required
3. Few component parts, particularly moving parts. Only 10 per cent as many parts as the average reciprocating engine
4. Absence of vibration
5. Adaption to many low-grade, nonexplosive fuels. Octane and cetane numbers do not influence the fuel's useability
6. Easily maintained with a minimum of man hours required to service the engine
7. Good cold weather starting characteristics, once ignition takes place. Some trouble has been experienced with initial vaporization at the fuel nozzles with low temperatures
8. Absence of ignition system, except in starting
9. Maximum fuel economy with maximum engine output
10. Low consumption of lubricating oil
11. Absence of external cooling system
12. Clean exhaust
13. Less objectionable exhaust noise.

Offsetting the advantages, there are the following disadvantages:

1. Higher fuel consumption than piston engines in all ranges
2. Poorest fuel economy in part-throttle operation
3. High rotative speeds of moving parts
4. Parts most subject to failure are high-cost items
5. Materials for some of the important components are high-cost, hard-to-obtain.

Of particular interest to automotive applications is the torque characteristic of the secondary turbine wheel, or driving unit. No mechanical connection exists between the compressor unit and the second-stage turbine unit. This feature allows the compressor unit to operate independently from the second-stage turbine unit, the only connection between the two being that of gas pressure. The secondary turbine wheel has torque characteristics which allow it to develop twice the normal operating torque when the wheel is stalled. In effect, the engine is also a torque converter with the ability to multiply torque progressively with decreasing speed until almost two



to one is reached at stall. This combined engine and torque converter is not penalized by the extra weight that usually goes with a torque converter installation.

It will be recalled that oil torque converters are limited in sustained torque multiplication by the heat rejection capacity of the converter cooling system. In automotive applications, sufficient cooling is provided for sustained operation above 70 per cent efficiency. Below 70 per cent efficiency, the duration of converter action is progressively more limited. This limiting factor does not necessarily hold with the gas turbine. As far as is known now, the secondary turbine can be held continuously at stall. Under this condition a slight increase in stack temperature occurs.

Characteristics of shaft speed versus torque and power are shown by the accompanying graph. The upward curving torque curve starts at the lower right at maximum speed torque, and slopes up to the stall point where the torque is almost doubled. As it extends to the left, the slope becomes less pronounced as full retarding power is approached. Horsepower available for driving the truck is shown on the right-hand side of the vertical scale. To the left of the vertical scale is plotted horsepower available for retarding—holding constant-grade descent speed. The retarding feature is unique inasfar as is known to date, and has every possibility of developing into a system which will greatly reduce the load on the service brake system of any vehicle so equipped. Lining wear will be reduced at the expense of increased fuel consumption since gas pressure produces the resistance to turbine wheel rotation.

It is interesting to note that the horsepower available for retarding roughly corresponds to a 4.5 per cent grade descent with 68,000 lb gross combined weight, the vehicle traveling at constant speed (without deceleration). The maximum horsepower available for hill climbing is 175 which will allow the vehicle to ascend an adverse 6 per cent grade at 9.3 miles per hour with 68,000 lb gross weight.

Future plans for the engine as a truck power plant call for a combination reduction gear and reverse gear in one box at the rear of the secondary unit. The output shaft in this new reversing box will drive through a pair of universal joints into a planetary transmission with six forward speeds and no reverse. The shaft of this transmission will drive directly into the rear axle assemblies. For the average highway freight job, an auxiliary transmission is not contemplated. It can be demonstrated that, by the proper spacing of gear ratios, sufficient top speed and sufficient gradeability in the lowest gear can be obtained without the use of an auxiliary transmission.

From a paper presented at the SAE National West Coast Meeting in Los Angeles, August 14-16, 1950.

Correction

In the abstract "Titanium and Zirconium Fabrication," which appeared in this section of the October issue, the authors were incorrectly identified through an error in makeup. The original paper was written by A. M. Bounds, Chief Metallurgist, and H. W. Cooper, Metallurgist, Superior Tube Co. To them and our readers, we apologize for this regrettable error.—THE EDITORS.

The Engineer's Stake In Public Relations

By John D. Waugh
Pendray & Leibert
New York, N. Y.

COMPARED to the struggles of other professions for favorable public recognition, engineering is twice blessed. Both its origin and its recent past have bequeathed it a favorable though not prominent public standing. In the minds of people who understand the creed, philosopy and contributions of engineering, the collective image of the profession is a positive one of objective research, constructive effort and service to mankind.

In spite of the generally favorable standing of engineering, there is evidence that the profession is not fully understood and appreciated by the general public. If you were to take a poll of passers-by on the street, asking each of them to name a great engineer, chances are they would scarcely be able to name one. Yet, most of these people could unhesitatingly name a great general, or a great statesman, or a poet, or actor, or even a great scientist.

At the community level there is widespread misunderstanding of an engineer's function, whatever his field. It has been said that an untold number of wives, when they state that their husbands are engineers, are asked, "With what railroad?" When exact titles are given, such as "stress analyst at the Concrete Airplane Corporation," members of the lay public still do not know what the engineer does. They are not interested in, and will not remember, unusual technical titles. They understand that doctors heal the sick, lawyers guide people's legal relationships, mechanics fix things, and so on. They will have to be told what engineers do to appreciate their place in the scheme of things.

Also in the community there appears to be an insufficient proportion of engineers who take the lead

in civic projects, organize worth-while activities, or speak before important civic groups. Program committees often consider technical people a bit dull and pedantic. If an engineer is suggested as a speaker, someone will tell about an engineer he knows, Harry Hemisphere. It is recounted that Harry won't say a ball is round, but will say: "It appears to be round at the prevailing temperature and under existing light conditions, but, without having proper instrumentation and criteria for round balls, I cannot risk my professional integrity by stating the ball is round."

Though this characterization may be overdrawn, there are many engineers whose analytical talents render them virtually inarticulate and hardly candidates for speaking appearances.

Companies, schools, and local and national engineering societies frequently find it difficult to get eminently qualified engineers to write interesting papers and present them effectively. Lay groups experience the same reticence. One result of this reluctance to lead is that the professional standing of engineering slips relative to the standing of other more active groups. Doctors and lawyers are social, civic, and political minded because their living depends directly upon the symbol they and their professions maintain.

Students at engineering schools periodically follow "fads" for certain branches of engineering that threaten the college with overstaffing in one field and shortages in others. At the seat of this difficulty is the failure of the profession, collectively, to present accurately the opportunities existing throughout engineering. Every engineer has a vested interest in the appropriate distribution of his fellow members throughout the profession. It there is disillusionment or displacement of engineers, or the profession loses its allure for capable young men, its future growth and standing are imperiled.

Organization and Machinery Available

To meet the problems facing their profession, engineers can undertake a program within the scope of their present activities by applying well-known public-relations principles. The profession is fortunate in having the organization and machinery to conduct a successful program for greater public recognition and appreciation. The national societies, with their experienced headquarters staffs and their network of chapters, form the ready-made organization. The machinery is provided by the general-circulation engineering publications, national, regional, and local-meetings programs and flow of paper presentations. What is needed additionally is a representative expression by members that they recognize their stake in public relations and want to do something about it.

An engineering public-relations program should include these objectives:

1. To gain wider public recognition of the role of the engineer in modern society. This would help maintain the prestige of the profession and assure its attraction for the best-qualified young men
2. To take definite steps in meeting threats to the profession. By clarification of the requirements and definition of the limits of the profession, shadowland "engineers" can be discouraged from using unqualified titles
3. To inform engineers how their stake in public relations has a direct bearing on their income and the security and prestige of their positions. The values of participating in social, economic, and political affairs at all levels would be emphasized.

If the engineering profession ever decides to follow a plotted course of improving its public relations, it will again be twice blessed: Because it has done tremendous good and promises to do very much more, and because it is not a pressure group, and the only axe it has to grind is that it wants to be known for the good work it has done and is doing.

From a paper presented at the ASME Fall Meeting in Worcester, Mass., September 19-21, 1950.

Styling Machine Tools

By Frank Burgess and Harold Sizer
Brown & Sharpe Manufacturing Co.
Providence, R. I.

ARE those who buy or specify machine tools influenced by appearance? Purchasers have long prided themselves on their practical evaluation of machine tools. They want facts—demonstrations of production rates, samples showing accuracy and surface finish, lubrication diagrams, material specifications, and assurances of long service life. Does appearance play any part in this practical appraisal? We believe it does.

A well-styled machine creates interest, and a buyer is ready to listen to the story of what the machine can do. The styling also can do a subtle but effective job in emphasizing the features of a machine. If a concern is offering a powerful machine, sturdy and rigid, with a reserve of power for tough cuts, the styling can suggest these qualities, and by its presentation of masses create the feeling of power or strength. Similarly, if a small "light-type" machine is being offered, which is sensitive and easily operated, the styling can subdue mass effects and suggest the light, responsive qualities it is desired to emphasize.

Function: In machine tools the practical requirements of the design come first, and function is not sacrificed or compromised for appearance. If 1 hp is needed, we cannot adapt a ½-hp motor just because it gives a more compact better-proportioned appearance on the machine column. If the convenient working height of a machine table is 40 inches above the floor, we cannot, like the artist painting bathing beauties, increase leg lengths to get more pleasing proportions.

The supremacy of function makes the job of a machine-tool stylist a difficult one. In general, little can be done by a final face lifting, and machines with after-thought ornamentation or "draped-on" effects show a lack of sincerity. The appearance so

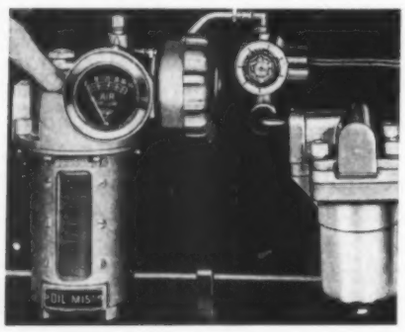
(*Continued on Page* 208)

NEW PARTS AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 191

Centralized Lubricator 1

Alemite Div., Stewart-Warner Corp., Chicago, Ill.



Designation: Oil-Mist

Style: Model 4955, air-lubricant mist, automatic solenoid controlled

Size: Lubricator—height 8½ in., width 6½ in., depth 4⅝ in., with solenoid valve—height 8⅝ in., width 6½ in., depth 4⅞ in.; air inlet, ¼-in. female PT; mist outlet, ⅜-in. female PT; water separator—height 6 in., width 3⅜ in., depth 3½ in.; inlet and outlet, ¼-in. female PT

Service: Shop air, 10 to 20 psi pressure, max consumption approximately 1 cfm; solenoid, 115 v a-c; up to 30 bearing inches (bearing inches = bearing ID, in.) per lubricator with 60 bearings max

Design: Air pressure regulator; needle valve oil flow control; air to lubricator solenoid controlled; oil can be delivered to bearings as mist or precipitated at point of delivery to solid oil

Applications: Automatic controlled delivery of lubricating oil to all types of machine bearings—ball and roller, plain, sliding, or rolling.

For more data circle MD 1, Page 191

Three-Way Midget Valve 2

Automatic Switch Co., 379-C Lakeside Ave., Orange, N. J.

Designation: Asco

Style: Packless, three-way universal, solenoid

Size: ⅛-in. pipe ports with $\frac{7}{64}$-in. flow hole; fits within 3½-in. cube; shipping weight, 1¼ lb; conduit connection, ½-in. IPS

Service: Air, gas, water, light oil, refrigerants and other fluids to 212 F; pressures to 125 psi (a-c), 50 psi (d-c); 115/230 v a-c 60 cycle, 115 v d-c; power consumption, 10 watts

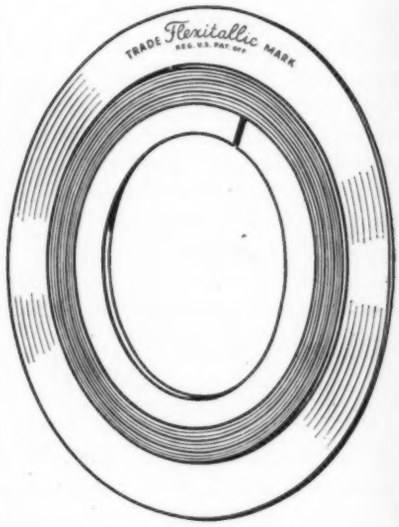
Design: Mounts in any position; body—brass or stainless steel bar stock; valve seat—crown type integral with body; valve disc—flat synthetic composition, chemical resistant; solenoid coils—NEMA Class B, 24-in. leads; conduit connection revolves 360 deg.; can be disassembled without removing from line

Applications: Fluid control circuits for diaphragm motors, measuring and testing apparatus, power cylinders; oil burners, gas heaters, dispensers, etc.

For more data circle MD 2, Page 191

High-Pressure Gasket 3

Flexitallic Gasket Co., Camden, N. J.



Designation: Flexitallic

Style: CGI, compression gage type, inside and outside ring

Size: All standard ASA and API fittings; special available; inside ring thickness varies with flange finish and gasket yield factors

Service: Hydraulic and highly corrosive fluids from 150 to 2500 psi

Design: Spiral-wound construction with alternating V-crimped plies of metal and filler in wide choice of materials including Teflon; solid reuseable inside rings prevent radial movement of gasket under high bolt loads, minimize contamination from fluids, fill flange recess to prevent flow turbulence—made of stainless steels, Monel, nickel, or Inconel

Applications: Compression flange sealing for fluid handling systems.

For more data circle MD 3, Page 191

Bond Testing of Bi-Metallic Bearing Materials-2

IN Part 1-Bond Testing of Bi-Metallic Bearing Materials we pointed out the importance of securing a definite *bond* between two or more metals in the production of quality bearings. While the only reliable tests available at this time are destructive in nature, they serve as an accurate gauge of quality during the manufacturing process. The test most widely used is the chisel test—Figure I.

If the alloy layer can be detected both on the overlay and the base metal, brittle bond is indicated. If the overlay metal is stripped clean from the base metal, then the bond is bad rather than brittle.

Tables II and III outline rating methods which can be employed to classify the results of the chisel test.

base babbitts containing tin, a bond number of 2 may be obtained. Tin alloys on steel usually have a bond number of 2 while on bronze the bond number may be 3, due to the fact that heavier layers of the brittle tin-copper compound are formed.

The presence of a brittle bond in a composite bearing material is not undesirable as long as the bond strength is high and the bearing is not subjected to heavy fatiguing stresses. Fatigue loads, which are of a cyclical, repetitive nature tend to flex the material back and forth, which flexing induces shear stresses in the bond layer. Brittle bond compounds are usually weak in shear strength, but in some cases, it has been found that material with a bond rating of number 4 will perform

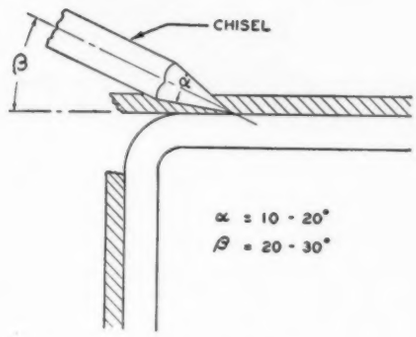


Figure 1—Chisel Test of Bond Bi-Metallic Bearing Materials

TABLE II

Bond Ductility Rating

Bond Number	Rating	Percent of Overlay Metal Fractured Along Bond Line
1	Good	0- 5
2	Good	5- 15
3	Fair	15- 40
4	Poor	40- 60
5	Bad	60-100
6	Bad	100

TABLE III

Bond Completeness Rating

Bond Number	Rating	Appearance of Chisel Marks
1	0	No tendency of two metals to separate.
2	0- 15	Separation at edge of chisel marks.
3	15- 40	Bond separates in spots.
4	40- 60	About 50% of base metal cleanly exposed.
5	60-100	More than 50% of base metal exposed.
6	100	Base metal completely exposed.

Lead alloys should have a bond number of 1 on steel backs, although with lead

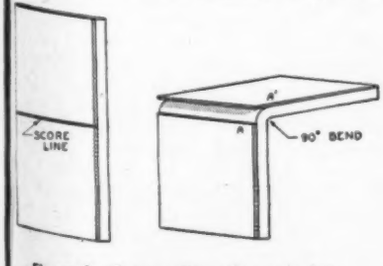


Figure 2—Preparation of sample for "Peel-Back" Test

satisfactorily in bearing applications. This is especially true of material such as bushing stock fabricated by sintering bronze powder on a steel backing. The bonding is not complete due to the natural porous structure of the bearing metal.

Also, the semi-quantitative value of the test does not signify that bond number 2 is faulty and, in many cases, a bond number of 3 is entirely acceptable.

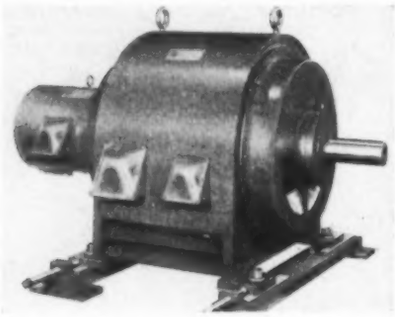
Further interpretation of bond strength by the chisel method is possible with the aid of a "peel-back" test. In this test, the specimen is bent 90 degrees on the backing metal which flexing promotes shear along the bond line and enables the tester to study the type and quality of the bond more thoroughly.

The "peel-back" test is illustrated in Figure II. The piece to be tested is placed in a special fixture, notched along the bearing surface and bent back over a fixed radius. The stretching action along the arc of the bend causes shear stresses to be set up in the bond layer. If the bond is brtitle or weak, the overlay will tear loose and can be peeled back. The distance A-A' that the metal peels back is one indication of the bond strength and quality. Further interpretation can be made by chiseling into the overlay from point A'.

NEW PARTS AND MATERIALS

Synchronous Motor 4

Electric Products Co., 1725 Clarkstone Rd., Cleveland 12, Ohio.



Style: Synchronous, open, drip-proof, splashproof, weatherproof; bracket, pedestal or flange

Size: 20 hp and up

Service: 514 rpm and up; 0.8 leading p.f.; any commercial d-c power supply

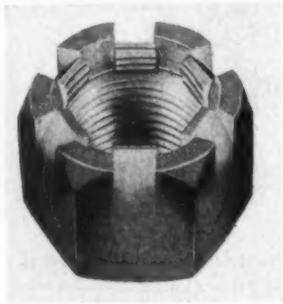
Design: Welded all-steel construction; special varnish insulation; one-to-one ratio pedestal bearings; adjustable slide belt tightening

Applications: For high-speed heavy-duty and special machine drives.

For more data circle MD 4, Page 191

Lock Nut 6

Boots Aircraft Corp., Stamford, Conn.



Designation: Hex-Lok

Style: Nut, hex head, locking

Size: 8-32 to 3/8-24

Service: Cadmium-plated steel for spec AN-N-5 to 250F and AN-N-10 to 550F; silver-plated stainless steel for 1200F; torque values controlled to special requirements

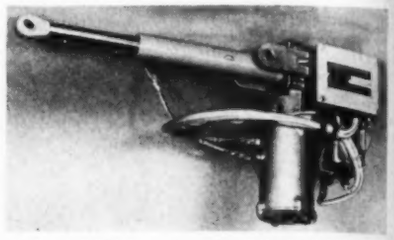
Design: Six threaded flanges depressed inward and downward for locking; vibration resistant

Applications: For all types of vibration-resistant fastening requirements on machinery.

For more data circle MD 6, Page 191

Actuator 8

Hydro-Aire Inc., Burbank, Calif.



Style: Linear, electromechanical

Size: Retracted overall length, 10.31 in.; height, 5.375 in.; width, 3.218

Service: 200 lb axial compression, 100 lb tension; piston travel, 2.31 in.; operating time, either direction, 8 seconds; duty cycle, one minute on, 15 minutes off; ambient temperature range, −100F to 165F; current drain, 2.5 amp; 115v a-c, single-phase 400-cycle

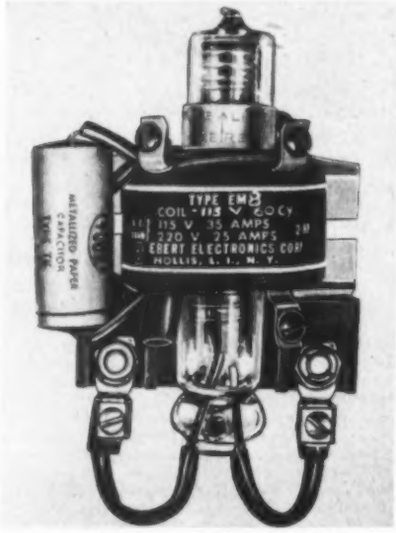
Design: Integral brake stops overtravel within 0.02-in. after power cutoff; positive nonjamming stops; adjustable load limit switches

Applications: For operation of carburetor preheat valves, turbo selectors, air shutters, etc.

For more data circle MD 8, Page 191

High-Power Relay 5

Ebert Electronics Corp., 185-09 Jamaica Ave., Hollis 7, L. I., N. Y.



Style: EM-8, Mercury plunger type

Size: 4¼ in. high, 2⅝ in. wide, 2¼ in. deep

Service: Load, 35 amp 115v, 30 amp 220 v, 20 amp 440 v; unlimited in-rush current; external contact power, 100 v, 8 ma a-c; power amplification, 10,000

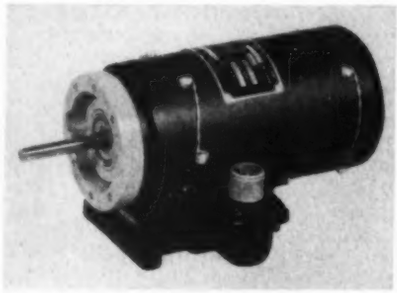
Design: Hermetically sealed mercury to mercury; energizing coil in resonant circuit; external contact merely detunes resonant circuit

Applications: Machine electric and electronic control circuits.

For more data circle MD 5, Page 191

High-Speed Motor 7

Lear Inc., 110 Ionia Ave., NW, Grand Rapids, Mich.



Style: Model CA-14B-3; flange or base mounting

Size: 1/15 hp; 3.08 x 3.72 x 5.06 in. long; weight, 2.44 lb

Service: Continuous duty, 4600 rpm; starting torque, 385% full-load torque; 26 v d-c; ambient temperature range, −65 to 165F

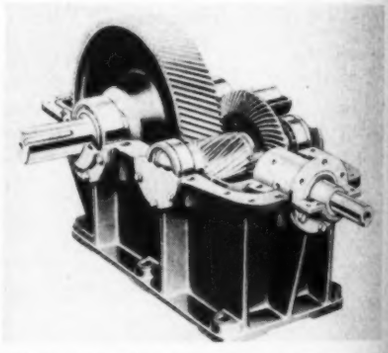
Design: Precision built for severe duty; corrosion resistant; optional features—clutch for positioning of friction load devices, electromagnetic brake for positioning control in applications which require locking or impose large load inertias on motor, thermal protector for maximum stress or overload conditions, radio noise filter to meet ANM-40 specs

Applications: High-speed precision control drive for aircraft and industrial equipment.

For more data circle MD 7, Page 191

Speed Reducer 9

The Falk Corp., Milwaukee, Wis.



Style: Right-angle, horizontal; GHB-single reduction, GDB-double reduction, GRB-triple reduction

Size: 15 to 1500 hp

Service: Occasional, intermittent or continuous duty; reduction—1.5:1 min., 515:1 max; input—1750 rpm and higher

Design: Shafts—heat-treated alloy steel in small sizes, SAE 1045 forged steel in large sizes; bearings—a straight roller and two tapered roller for high-speed shafts, double row tapered for sprocket or pulley connected low-speed shafts, tapered roller all other shafts; gears—spiral bevel precision cut carburized and lapped in first reduction, single helical precision cut and shaved in other reductions; lubrication—continuous splash system

Applications: General purpose and special machine drives.

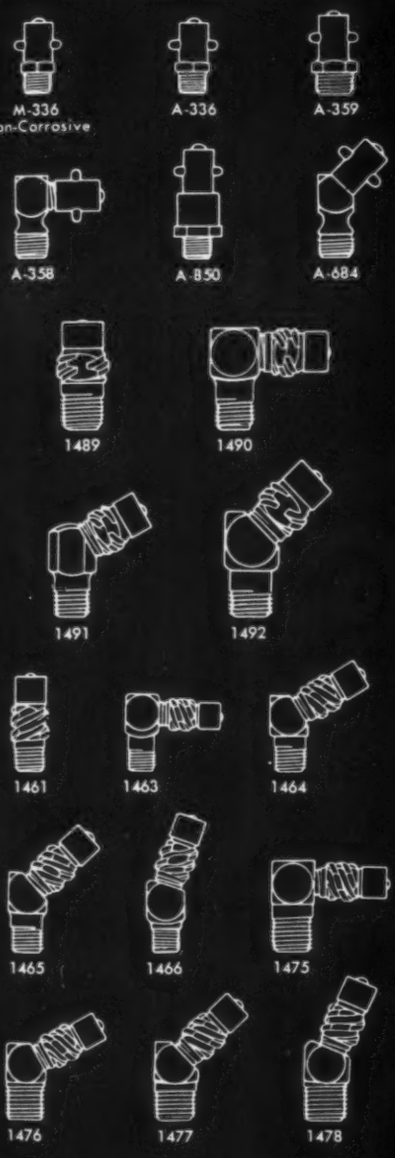
For more data circle MD 9, Page 191

Genuine ALEMITE LUBRICATION FITTINGS

DATA SHEET **NO. 3**

Useful Information to Help You Select and Specify the Right Alemite Fitting for Every Bearing

Simplify ORDERING, INSPECTION and INVENTORY CONTROL. Specify Alemite part numbers on your blueprints.



PIN TYPE FITTINGS

The original lubrication fitting developed by Alemite. Named after the positive locking of the Pin Type Coupling on the cross pin of the fitting.

PART NO.	THREAD SIZE	FITTING ANGLE	LENGTH OVERALL
A-336	⅛" P.T.	Straight	1"
M-336	⅛" P.T.	Straight	1"
A-359	¼" P.T.	Straight	1 5/16"
A-358	⅛" P.T.	90°	1 1/16"
A-850	⅛" P.T.	Straight	1 21/64"
A-684	⅛" P.T.	45°	1 5/16"

MOGUL DOT FITTINGS

Similar to the Dot Fittings above, except larger and more rugged to withstand hard industrial use on heavy machinery.

PART NO.	THREAD SIZE	FITTING ANGLE	LENGTH OVERALL
1489	¼" P.T.	Straight	1 7/16"
1490	¼" P.T.	90°	1 11/16"
1491	¼" P.T.	60°	1 21/32"
1492	¼" P.T.	45°	2"

STANDARD DOT FITTINGS

Commonly used on heavy duty machinery such as contractors' equipment, wood working machinery, canning machinery, etc. Gun coupling screws on to the fitting thread, making a positive seal.

PART NO.	THREAD SIZE	FITTING ANGLE	LENGTH OVERALL
1461	⅛" P.T.	Straight	1 15/64"
1463	⅛" P.T.	90°	1"
1464	⅛" P.T.	60°	1 13/32"
1465	⅛" P.T.	45°	1 21/64"
1466	⅛" P.T.	20°	1 13/16"
1475	¼" P.T.	90°	1 3/16"
1476	¼" P.T.	60°	1 7/16"
1477	¼" P.T.	45°	1 21/64"
1478	¼" P.T.	20°	1 7/8"

ALEMITE

Modern Lubrication Methods That Cut Production Costs

FREE! Complete set of four Data Sheets similar to this, giving specifications on all types and sizes of Alemite Lubrication Fittings. Simply write to Alemite, Dept. R-120, 1850 Diversey Parkway, Chicago 14, Illinois.

Another Product of STEWART WARNER

NEW PARTS AND MATERIALS

Braided Packing 10

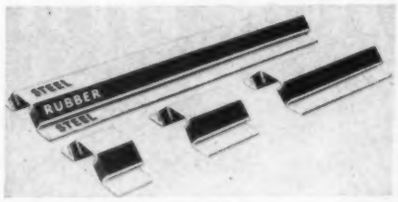
Greene, Tweed & Co., North Wales, Pa.

Designation: Palmetto 1330
Form: Braided blue asbestos yarn impregnated with Teflon
Size: From ⅛-in. sq. and up; 1-lb spools, 5½ and 13-lb boxes, or 25, 50 and 100-lb reels
Service: Corrosive chemicals and solvents from −150F to 550F
Properties: Easily cut or formed; high chemical resistance; self-lubricating; leakproof
Applications: Fluid handling systems; chemical processing.

For more data circle MD 10, Page 191

Vibration Mount 12

Finn & Co., 2850 Eighth Ave., New York 30, N. Y.

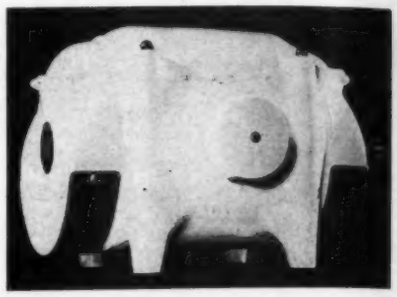


Designation: Finnflex
Style: No. 9 channel type
Size: Any length to 18 in.
Service: Vibration damping; four rubber stiffnesses for loads of 40, 50, 70 and 105 lb per in. length at ¼-in. deflection
Design: Steel channel floated in rubber between two steel angles; spring index is not constant, resonance avoided
Application: Isolating all types of machines and equipment against vibration.

For more data circle MD 12, Page 191

Sanitary Motor 14

U. S. Electrical Motors Inc., 200 Los Angeles 54, Calif.



Style: CT, totally enclosed, foot or flange mounted
Size: ½ to 2 hp
Service: 1800 rpm; 55C temperature rise; a-c
Design: Baked white enamel finish; smooth self-draining exterior; sealed terminals; water sealed bearings; asbestos protected windings; rustproof fittings; hollow feet for through stud mounting; full clearance under motor for cleaning
Applications: Drives for food processing and handling machinery.

For more data circle MD 14, Page 191

High-Speed Air Motor 11

Bellows Co., Akron, O.

Style: BSSM Series double-acting cylinders; electronic or manual control valve; foot, pivot or front flange mountings; rear flange, foot or pivot with remote control
Size: Stroke lengths, 4, 6, 9 or 12 in; bores, 2½ or 3⅝ in.
Service: Air pressures, 60 to 100 psi recommended, 5 to 175 psi max., rod speeds 6 to 10 times standard cylinder speeds; power to punch ½-in. hole in 1/16-in. mild steel
Design: Built-in accumulator and quick-release valve; integral directional valve; built - in operating and speed controls; high-speed advance, slow retreat strokes, both high-speed strokes special
Applications: For machines requiring high-speed high-power strokes for staking, riveting, forming, swedging, and punching operations or for cutting of continuously moving materials such as in extruding and for flash trimming of moldings or castings in plastics or metals.

For more data circle MD 11, Page 191

Control Motor 13

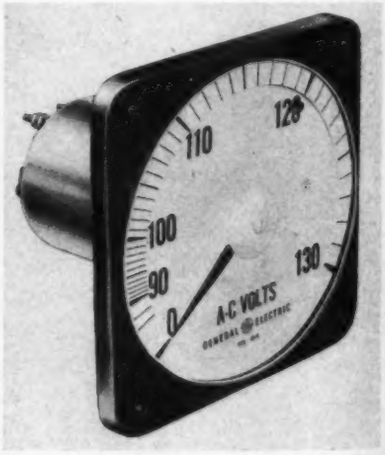
Gleason-Avery Inc., Auburn, N. Y.

Designation: Boostar
Style: Enclosed motor, rack and automatic safety return; straight-line operation
Size: 3½ to 3¾ in.; weight, 3 lb
Service: Automatic heat control and control during power failure; power lifts approximately 23 lb (direct pull) 4 in. in 30 seconds; requires 3 to 5 lb spring; primary excitation, one watt; 110 v 60-50 cycles a-c
Design: Chassis mounts in any position; all terminals housed outside case; external transformer; oil-retaining bronze bearings; circuit closed — motor driven rack moves to left, circuit open (power failure)—spring returns rack bar to right
Applications: Shut off use, air conditioning applicators, door operation, furnace fire control, etc.

For more data circle MD 13, Page 191

Voltmeter 15

General Electric Co., Meter and Instrument Divs., Schenectady 5, N. Y.

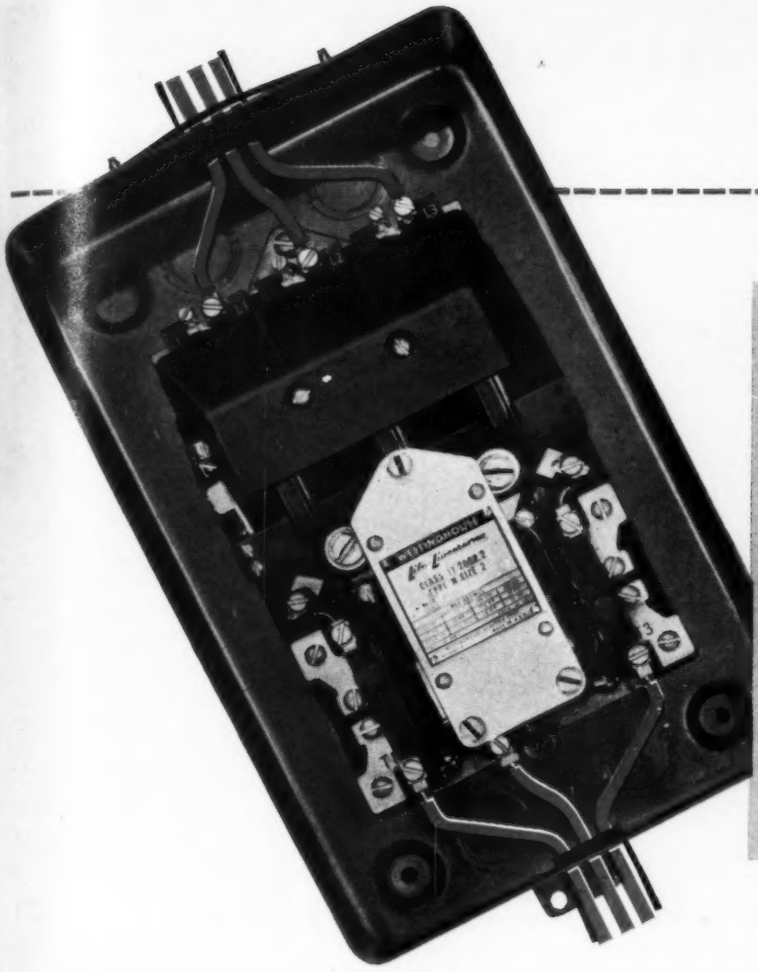


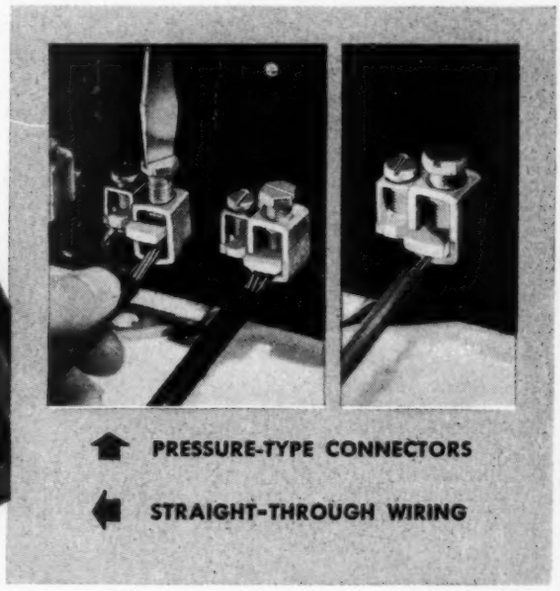
Style: AB-16 (a-c); DB-16 (d-c)
Size: 8¾ in. square; scale, 250 deg., 14.2 in. long
Service: Long-range reading, 130 v
Design: Protruding convex glass cover for flush mounting; shock-resistant spring-mounted jewels; magnetic damping for quick response; dustproof, moisture-resistant cases having steel shell with Textolite base and die-cast cover
Applications: For use on swinging brackets or other installations remote from the control station.

For more data circle MD 15, Page 191

YOU CAN BE **SURE**.. IF IT'S

Westinghouse





NEW Life-Linestarter*

cuts installation costs 4 ways!

Savings start before they are put in operation . . . with the new Westinghouse Life-Linestarter. New design features permit faster, easier installation—

1. **Straight-through Wiring**—Plainly marked line terminals are *all* at top—load terminals *all* at bottom, permitting simple, straight-through wiring with uniform lead lengths. All terminals are easily reached from the front.
2. **Pressure-type Connectors** speed the job and provide a positive low-resistance connection for either solid or stranded conductor, in a range of sizes to cover all ratings.
3. **NEMA Standard Mounting**—Open starter units conform to the new NEMA mounting dimensions, also to the NEMA sequence of wiring, permitting interchangeability.
4. **Deep-drawn Lift-off Cover**—Exposes unit for easy access. Fastens securely. May be padlocked. No hinge trouble.

The Life-Linestarter cuts costs in other ways, too—uniformity and completeness of line (NEMA sizes 0 through 4, to 100 hp, 600 volts) . . . superior performance . . . positive protection. Ask your Westinghouse representative to show you "the inside story"—a Trans-Vision presentation. Or write for booklet B-4677. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-30025

*Trade Mark

Westinghouse

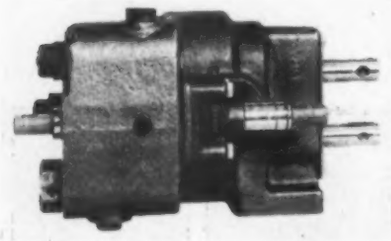
Life-Linestarter

TOMORROW'S STARTER—TODAY!

NEW PARTS AND MATERIALS

Hydraulic Pump-Valve 16

Commercial Shearing & Stamping Co., Youngstown, O.



Style: B101 series; pump and control-valve combination

Size: 1½, 2, 2½ in. pipe ports

Service: Intermittent oil hydraulic duty to 1500 psi

Design: Two drive shafts for connection to power take-off shaft having either rotation; push-pull balanced-spool control valve with raise, hold and lower positions; optional relief valve if desired—single-stage or two-stage

Applications: Actuating hydraulic dump units, etc.

For more data circle MD 16, Page 191

Phenolic Laminate 18

Richardson Co., 2793 Lake St., Melrose Park, Ill.

Designation: Insurok, T-812

Form: Paper-base phenolic laminate sheet

Size: Wide range of sheet sizes and thicknesses

Service: High-frequency insulation; resistance, 1,000,000 megohms ($\frac{1}{8}$-in. sheet) after humidity conditioning

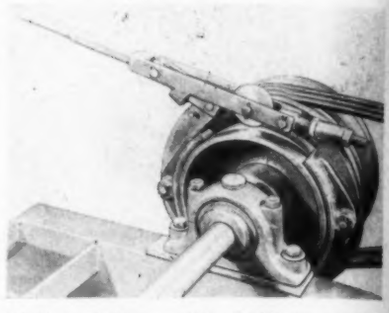
Properties: Moisture absorption, 0.38% (24 hours); tensile strength, 19,500 psi (main direction), 14,500 psi (cross direction); flexural strength, 23,000 psi (main direction, 18,000 psi (cross direction); dielectric strength (perpendicular to laminations), 725 volts per mil, short time; punches readily into intricate shapes

Applications: Radio, television and electronic equipment parts.

For more data circle MD 18, Page 191

Reduction Pulley 20

Hart Reduction Pulley Co., Milwaukee 3, Wis.



Style: Pulley with built-in clutch and overload release; V-belt or chain drive; double clutch for low and high speed or forward and reverse

Size: 4000 and 6000 lb-in. torques; larger and smaller to be available

Service: Internal pulley reduction 2½:1 to 100:1; total reduction including V-belt or chain motor to pulley drive, to 400:1

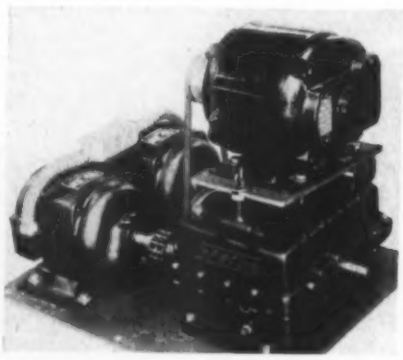
Design: Interlocking clutch control; cam and roller overload release

Applications: Machine drives with speeds below standard motors.

For more data circle MD 20, Page 191

Variable-Speed Drive 17

Speed Control Corp., 1450 E. 298 St., Dept. C-19, Wickliffe, O.



Designation: Specon OOED

Style: Motor-generator-differential, nonreversible and reversible

Size: Nonreversing, ½ hp; reversing, 1/3 hp

Service: Nonreversing output —0 min 250 to 1000 rpm max; reversing—±150 to ±600 rpm; direct coupling; max torque at zero speed

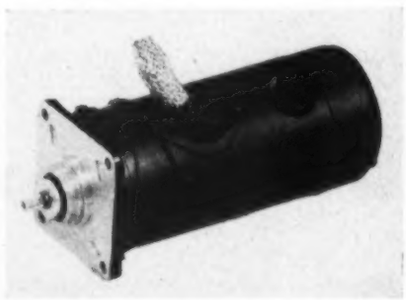
Design: Standard a-c motor coupled to two d-c motors through differential gear box; d-c motors connected in closed loop, require no outside source; all reversing action occurs in differential, motors nonreversing

Applications: For machine drives requiring increased torque at low speeds.

For more data circle MD 17, Page 191

High-Speed Motor 19

Lear, Inc., 110 Ionia Ave. NW, Grand Rapids, Mich.



Style: Model BC-05C-1

Size: 1/50-hp; 1.87 x 1.57 x 3.66 in. long; weight, 0.82 lb

Service: Duty cycle, 3 min. on, 17 min. off; 15,000 rpm; starting torque, 400% full-load torque; 26 v d-c; ambient temperature range, —65 to 165F

Design: Precision built for severe duty; corrosion resistant; optional features—clutch for positioning of friction load devices, electromagnetic brake for positioning control in applications which require locking or impose large load inertias on motor, thermal protector for maximum stress or overload conditions, radio noise filter to meet ANM-40 specs

Applications: High-speed precision control drive for aircraft and industrial equipment.

For more data circle MD 19, Page 191

Control Valve 21

Sterling Inc., 3738 N. Holton St., Milwaukee 12, Wis.

Designation: Sterlco

Style: Series 150E; direct-acting for heating (valve closes as bulb temperature rises), reverse-acting (valve opens as bulb temperature rises)

Size: ½, ¾ and 1-in. pipe ports

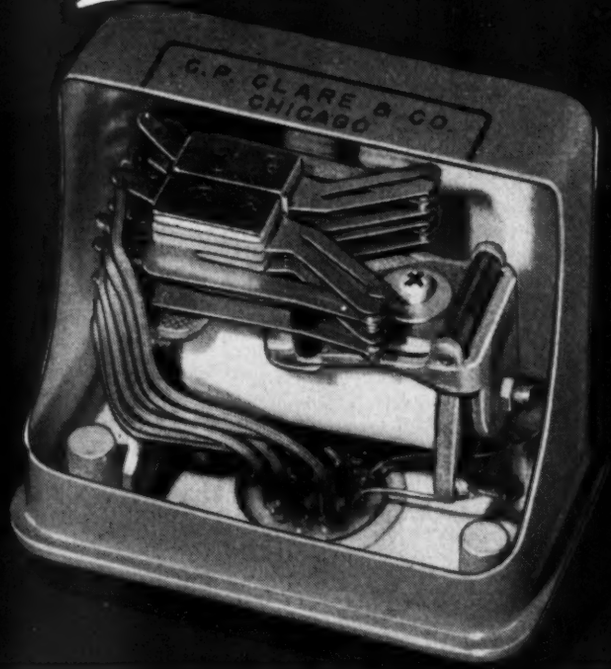
Service: Water, oil, steam or other fluids; 125 psi max pressure; constant temperature control adjustable over wide range; flow automatically modulated

Design: Bellows-packed valve, stainless steel trim and monel bellows; capillary tube; thermostat bulb; mounts any position

Applications: For automatic control of fluid heating or cooling circuits on machines or equipment utilizing heat exchangers.

For more data circle MD 21, Page 191

CLARE RELAYS



Here Is What CLARE Hermetic Sealing Means:

After assembly in the container, the enclosure is attached to a high vacuum pump and pumped down to a few microns pressure to remove all traces of moisture and gases.

While under this extreme vacuum, the enclosure and seals are tested for leaks by means of a Mass Spectrometer—a device so sensitive that it can detect a leak so tiny that more than thirty-one years would be required for one cubic centimeter of air to pass through it. This highly refined method of leak testing causes rejection of many enclosures which could pass the usual immersion tests without detection.

For most applications, the enclosure is then filled with dry nitrogen, which has a relatively high arcing potential.

Write for CLARE Bulletin No. 114

CLARE Hermetically Sealed Relays Protect Against These Conditions:

- Moisture, High Humidity and Ice
- Salt Air and Spray
- Fungus Growth
- Varying Air Pressure
- Variation of Air Density
- Dust and Dirt
- Corrosive Fumes
- Explosive Atmospheres
- Tampering

Clare Hermetically Sealed Relays are *air-tight* so that no gas or spirit can enter or escape.

This ideal condition, now available to every user of CLARE hermetically sealed relays, is the result of many years of painstaking research by the CLARE organization to produce a perfectly sealed relay at a reasonable cost to industrial relay buyers.

Hermetically sealed in an ideal atmosphere of dry inert gas, they are permanently immune to the difficult climatic and environmental conditions responsible for 95% of the failures of exposed electrical apparatus.

CLARE has today—or can provide you with—the hermetically sealed relay that you require. Over forty different series of CLARE hermetically sealed relays are described in Bulletin No. 114. Within each series, innumerable variations of coil and contact specifications are possible. Numerous other special sealed-relay units are also available.

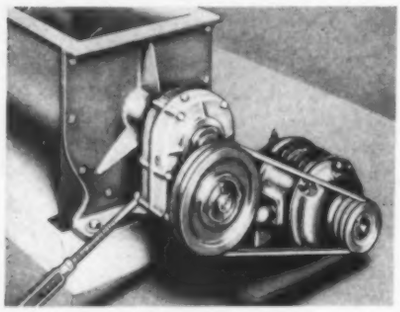
Clare sales engineers are located in principal cities to assist you in the selection of just the right relay for your specific requirement. Look them up in your telephone directory or write: C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

NEW PARTS AND MATERIALS

Speed Reducer 22

Dodge Mfg. Corp., Mishawaka, Ind.



Style: Shaft-mounted; V- or flat-belt drive; single reduction

Size: Four sizes to 27 hp

Service: Output, 115 to 330 rpm

Design: Secured to shaft with steel locking collars; anchored with torque arm; belt adjustment by turnbuckle; interchangeable shaft-keyed adapter bushings; machined cast-iron housing; deep-groove ball bearings; heat-treated helical gears, shaved; positive backstop to prevent load direction reversal

Applications: Reduction drive speeds for machines.

For more data circle MD 22, Page 191

Lightweight Belt 24

Baldwin Belting Inc., 74-76 Murray St., New York 7, N. Y.

Designation: Supertex

Style: Endless, 3-ply, 5-ply, brown or white

Size: Thickness — 3-ply 7/64-in. (white), 5/64-in. (brown)—5-ply 11/64-in. (white), 9/64-in. (brown); any width to 48 in.; duck weight, 9 oz.

Service: Oil and waterproof; acid and alkali resistant; nontoxic; loading per in. width 48 lb (3-ply), 80 lb (5-ply); minimum pulley diameters 1 in. (3-ply), 1½ in. (5-ply); tensile strength per in. width 420 lb (3-ply), 700 lb (5-ply); stretch at rated capacity, 1%; max temperature, 250F; friction between plies, 12-17 lb.

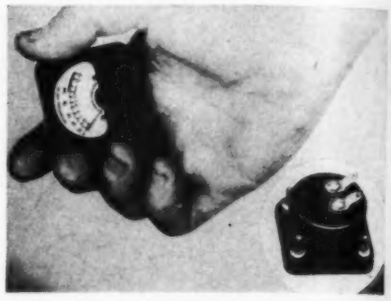
Design: Lightweight duck with neoprene rubber between all plies; raw edge construction; spliced with multiple step lap; smooth neoprene cover

Applications: For light conveying and power transmission machinery; especially suitable for food processing equipment.

For more data circle MD 24, Page 191

Audio Signal Meter 26

International Instruments Inc., New Haven 11, Conn.



Style: VU and Db; square, round and round flange mounting cases, all waterproof

Size: 1½-in. case; scale, 1.3-in. arc

Service: Specification JAN-I-6; dielectric strength, 1500v

Design: D'Arsonval type; self-contained subminiature movement; scales are black on white or in reverse; round case with O-ring seal, round flange with commercial seal for panel mounting

Applications: For measuring strength of audio signals in radio TV and communication systems and armed services equipment.

For more data circle MD 26, Page 191

Motor Starter 23

Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Designation: Motor Sentinel

Style: Class 10-023, double-pole, manual

Size: 1 hp, max; NEMA type I enclosure

Service: 250 v a-c, or d-c

Design: Bonderized die-cast aluminum; straight-through wiring, front terminals; over-center self-indicating toggle; positive bimetallic overload protection; indicating light

Applications: Starting and protecting small a-c and d-c motors used with fans, pumps, washing machines, compressors, etc.

For more data circle MD 23, Page 191

Overspeed Governor 25

Synchro-Start Products Inc., 1046 West Fullerton Ave., Chicago 14, Ill.

Style: Model GFA (automatic reset); model GFM (manual reset)

Size: Height, 5 in.; weight, 3 lb

Service: Adjustable control of internal-combustion engines

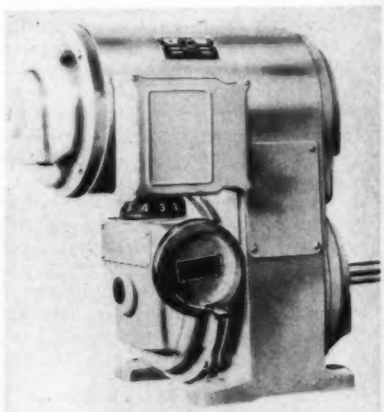
Design: All-metal construction with mounting bracket; sealed ball bearings; standard take-off for heavy-duty tachometer drive for use with a flexible shaft; can be adjusted while operating

Applications: Governing speed of internal-combustion engines and associated driven machines.

For more data circle MD 25, Page 191

Adjustable-Speed Drive 27

Sterling Electric Motors Inc., Los Angeles 22, Calif.



Style: Single-phase, capacitor type

Size: ½ to 3 hp; standard NEMA mounting dimensions

Service: Infinite speed variation within the ratios, 2:1, 3:1 or 4:1; 18 different max speeds from 2000 to 52 rpm; speed does not vary under fluctuating load conditions

Design: Fingertip speed control; one-piece cast-iron dripproof frame; "herringbone" design rotor; vinol-acetal insulated wire stator windings; new starting relay which eliminates centrifugal switches or rotary devices such as throw-out switches, commutators, brushes, etc.

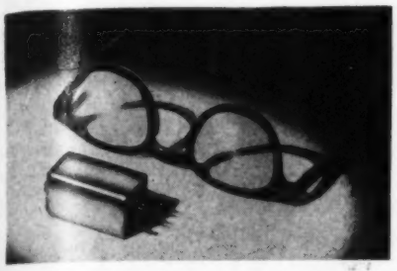
Applications: General machine drives requiring variable range of speeds.

For more data circle MD 27, Page 191

NEW PARTS

Miniature Relay 28

Sigma Instruments Inc., Boston 21, Mass.



Style: Hermetically sealed; any combination to DPDT

Size: 1 in. sq. by 1¾ in. high, exclusive of terminals

Service: DP unit—sensitivity, 40 mw, withstands 10 *g* vibrations at frequencies in excess of 60 cps; 2 to 1 margins for 'operate' and 'release' current permits sustained accelerations to 50 *g*

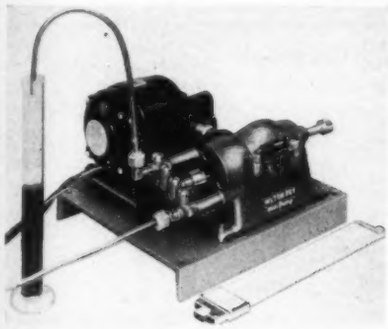
Design: Switch coupled to armature to eliminate wear effect on pull-on and drop-out points

Applications: Electrical machine relay control circuits.

For more data circle MD 28, Page 191

Metering Pump 29

Milton Roy Co., Philadelphia 18, Pa.



Style: Positive displacement reciprocating plunger, simplex, duplex and multiplex models

Size: Plunger, ⅛-in. diameter; valve, ⅝-in. width, 3-in. overall length; check balls, 3/16-inch

Service: Clear fluids such as perfumes, odorants, dyes, vitamins, antifreeze, etc.; 3 cc to 800 cc per hour; operating pressures to 1000 psi; accuracy, 99+%

Design: Powered by fractional gearhead motor; plungers cam-actuated; stroke adjustable from zero to capacity; double ball-check delivery; bearings, self-lubricated; liquid end and plunger, Carpenter 20 stainless steel; ball checks, 440 stainless steel, glass or synthetic sapphire

Applications: Accurate metering in laboratory and research work, pilot plant and small-scale operations.

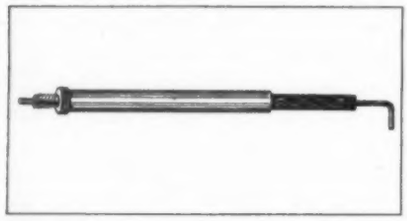
For more data circle MD 29, Page 191

ENGINEERING DEPARTMENT

EQUIPMENT

Tension Tester 30

All-Weather Springs, New York, N. Y.



Styles: Push-pull terminals; alligator clamp; insulated thong

Service: 12 oz to 12 lb

Design: Simple, compact tubular design, direct reading scale

Applications: Testing tensions or pressures in instruments, etc., in field or factory; insulated thong style for brush tension testing.

For more data circle MD 30, Page 191

Beam Compass 32

V & E Mfg. Co., Pasadena 20, Calif.

Style: Rectangular beam

Service: Large-scale pen, pencil or divider drafting; radii, 8¼ to 12 in.; special extensions for radii to 6 ft; 4-in. rack for slow-motion micrometer adjustment

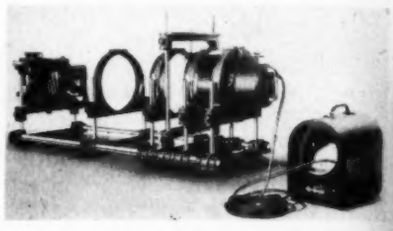
Design: Beam — ¼-in. hard-rolled structural aluminum alloy; legs—chrome plated cold-rolled steel, detachable from slide and interchangeable, extend one inch below beam; holders—steel points, split clamp and screw type; sliders and coupler—chrome plated cold-rolled steel; clamp screws — stainless steels

Applications: Precision inking, scribing on tool steel and other metals, heavy-duty all-pencil drafting, etc.

For more data circle MD 32, Page 191

Polariscope 34

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.



Style: Type 1534-A; horizontal

Size: 36 x 14¼ x 16½ in.; 32 lb

Service: 8-in. field; 0.00004-second exposure; horizontally adjustable and vertically adjustable over nine inches; camera aperture f/4.5

Design: High-speed, high-power stroboscopic lamp; diffuser; polarizer; straining bridge; analyzer; filter camera; degree scale for isoclinic determination.

Applications: For viewing and photographing stress patterns in plastic models by polarized light.

For more data circle MD 34, Page 191

Strain Recorder 31

The Baldwin Locomotive Works, Philadelphia 42, Pa.

Style: Electronic, single strip-chart

Size: Ranges 0-2000, 0-5000 and 0-10,000 microinches per inch

Service: For SR-4 strain gages, 120 1.2 ohms resistance, 1.9 and 2.2 sensitivity factor; ten chart speeds, ¾ to 720 in. per hour

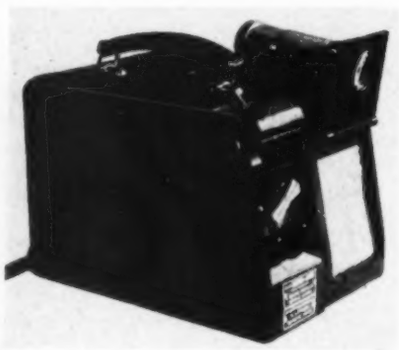
Design: One gage active and other for temperature compensation or both gages active for combined bending-tensile stress or strain

Applications: Continuous measurement of surface strain.

For more data circle MD 31, Page 191

Oscillograph 33

Sound Apparatus Co., Stirling, N. J.



Style: Straight-line, rectangular coordinates (not curved)

Size: 10 x 8 x 7 in., 13 lb

Service: Frequency range, 0 to 600 cycles; measuring range, 5 to 160v; max amplitude, 2 x 30 = 60 mm; sensitivity, 0.1 mm/v; impedance, 2700 ohms

Design: Ten selectable paper speeds; pen closes automatically when instrument not in use; record on transparent paper which can be projected and reproduced

Applications: For recording electrical oscillations.

For more data circle MD 33, Page 191

Oscillograph 35

Consolidated Engineering Corp., Pasadena 4, Calif.

Style: Type 5-116 electronic; optional transmissions, mounts, traces

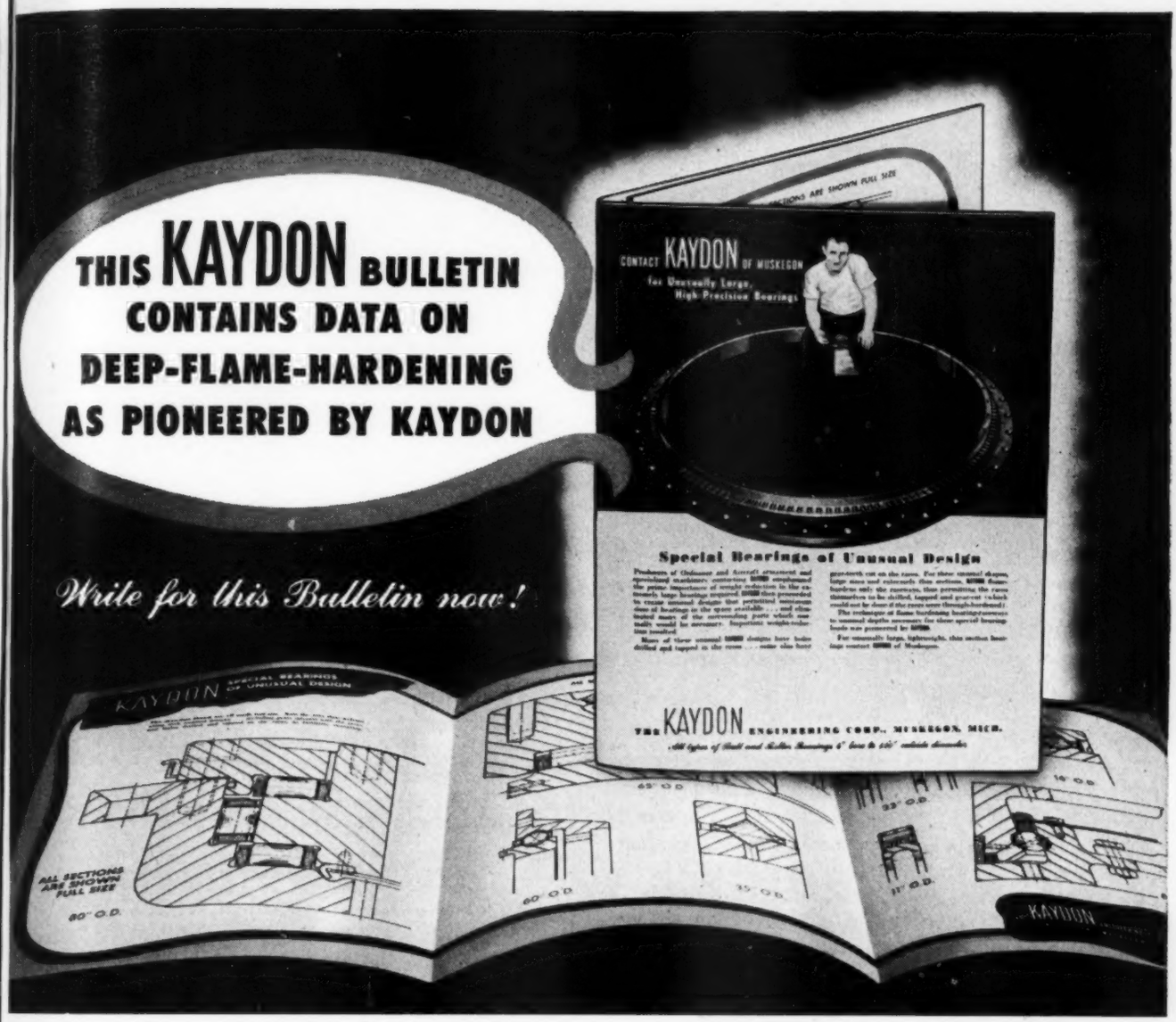
Size: Length 19½ in., width 9½ in., height 9 in., weight 42½ lb; 125 ft of 5-in. recording material

Service: Trace block capacity, 9 or 14; record speeds, ¼ to 100 in./sec; writing speeds, 25,000 in./sec (standard), 50,000 in./sec (optional); 0.1 and 0.01-second timing lines; power, 24 to 28 v d-c or 115 v 60-cycle a-c

Design: Change gear transmission, ten-speed quick-change gearshift optional; automatic record numbering, one counter for both viewing and recording; series 7-200 galvanometers

Applications: For measuring electrical oscillations.

For more data circle MD 35, Page 191



The KAYDON *technique of deep-flame-hardening for bearings of unusual shapes, sizes and thin sections*

Designers and users of special machinery will appreciate this information on **KAYDON**-pioneered deep-flame-hardening which has helped remove bearing-limitations that heretofore proved to be serious handicaps.

This new **KAYDON** technique in deep-flame-hardening hardens only the raceways of the bearings. This permits the races themselves to be accurately drilled, tapped and gear-cut . . . eliminates many of the surrounding parts which normally would be necessary . . . results in important weight-reduction . . . makes possible the creation of unusual designs that accommodate minimum sizes of bearings in the space available . . . permits unusual shapes, very large diameters, and extremely thin sections, all of which greatly facilitate mounting.

Write for this Bulletin on **KAYDON** Deep-Flame-Hardening . . . and when you need the unique services offered, contact **KAYDON** of Muskegon.

KAYDON Types of Standard or Special Bearings: Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust

THE KAYDON ENGINEERING CORP., MUSKEGON, MICH.

• ALL TYPES OF BALL AND ROLLER BEARINGS 4" BORE TO 120" OUTSIDE DIAMETER •

MEN OF MACHINES

C. E. Willis

Lear Inc. announces the appointment of **C. E. Willis** as chief engineer. A mechanical engineer, Mr. Willis was previously associated with the Fairchild Engine and Airplane Corp. as staff engineer, during which time he did extensive work relating to aircraft heating and ventilating problems and aircraft power plants. He is a former chief engineer and general manager of Aero Engineering Inc., and a former project engineer for Curtis Wright where he worked on the development of the XSC-1 and C-46 aircraft. In his new capacity Mr. Willis will be applying at the design level the benefits of his extensive experience in solving aircraft accessory equipment problems.

•

W. R. Spiller

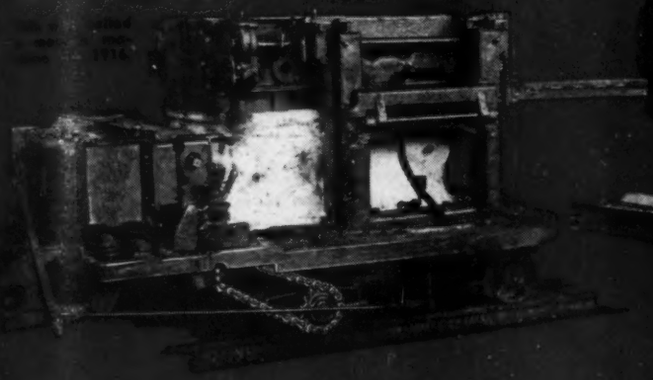
W. R. Spiller, assistant vice president of the Harris-Seybold Co., has been appointed chief engineer. Mr. Spiller has been associated with the design of heavy machinery for twenty-eight years—the last twelve being with the Harris-Seybold Co. He is an engineering graduate of the University of Pennsylvania and holds thirty patents.

•

Charles D. Perrine Jr., specialist in missile homing guidance systems, has joined the electronics and guidance section in Consolidated Vultee's San Diego Divi-

1905

1916



1933

THROUGHOUT NEARLY A HALF CENTURY

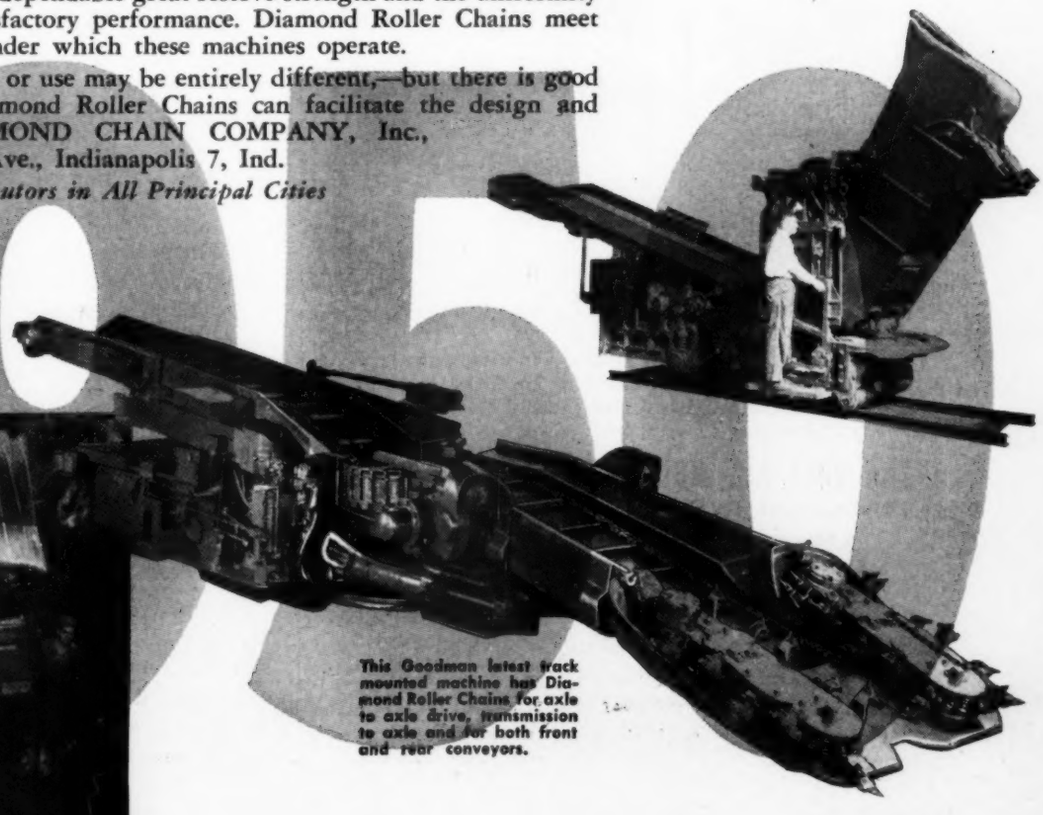
Powerful Goodman Machines Have Been Equipped With DIAMOND ◆ Roller Chains

• Pioneer builder of rugged, fast production mining machinery, Goodman has had nearly a half century experience with Diamond Roller Chain Drives.

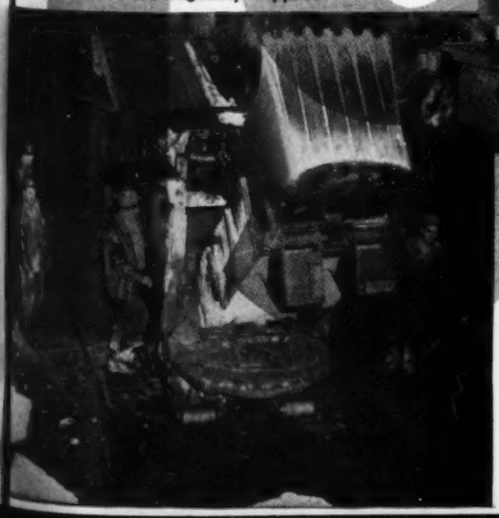
For such tough work, the dependable great reserve strength and the uniformity of quality are vital to satisfactory performance. Diamond Roller Chains meet all the severe conditions under which these machines operate.

The machinery you build or use may be entirely different,—but there is good reason to believe that Diamond Roller Chains can facilitate the design and improve operation. DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Ave., Indianapolis 7, Ind.

Offices and Distributors in All Principal Cities



And on Goodman "Conway" Shovels that have established records in muck handling in tunnels, and in coal and metal mines, Diamond Roller Chains for drives and conveyor operation are regularly supplied.



This Goodman latest track mounted machine has Diamond Roller Chains for axle to axle drive, transmission to axle and for both front and rear conveyors.

sion Engineering Department. Mr. Perrine will specialize on missile guidance problems and electronics.

♦

William F. Pioch has been appointed manager of manufacturing engineering of the newly formed Aircraft Engine Division of the Ford Motor Co. Mr. Pioch joined Ford in 1912 as a tool designer. In 1921 he was named assistant chief tool engineer for the company and was promoted to chief tool engineer in 1926. He served in that capacity until assigned to Willow Run bomber plant as chief engineer.

♦

Joseph S. Jacoby Jr. recently joined the Capehart-Farnsworth Corp. as assistant chief engineer.

♦

A. R. Kelso has been elected vice president of Mack Trucks Inc. Mr. Kelso has been previously connected with Hudson Motor Car Co., Continental Motors Corp. and Motor Products Corp.

♦

Alex D. Matheson has been appointed general manager of French and Hecht Division, Kelsey-Hayes Wheel Co.

♦

The Falk Corp. announces the promotions of several members of its engineering department. **George P. Maurer** has been named assistant chief engineer, Gear Technology. **W. Stephen Richardson** is new assistant chief engineer, Applications and Special Products. **Edward J. Wellauer** has been appointed assistant chief engineer, Materials and Research.

♦

Dr. John T. Rettaliata, dean of engineering at Illinois Institute of Technology, becomes vice president for academic affairs.

♦

Abart Gear & Machine Co. announces the appointment of **O. W. Klima** as chief engineer. Since graduating from Armour Institute of Technology, Mr. Klima has specialized in power transmission equipment and machine design.

♦

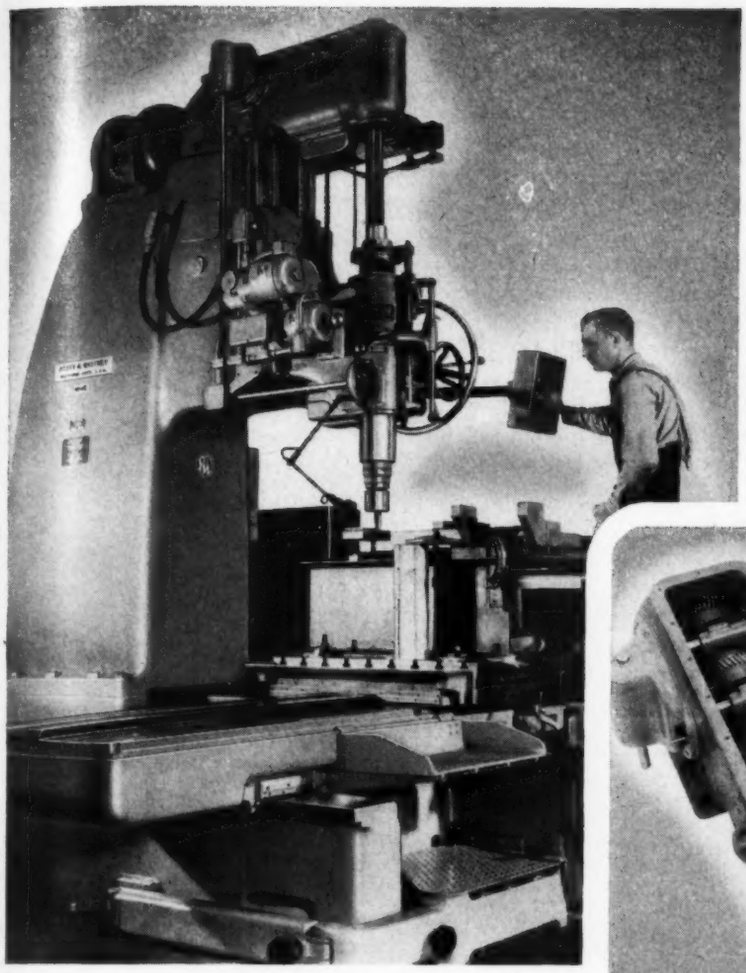
Westinghouse Electric Corp. has announced the appointment of **Carl F. Herbold** as director of manufacturing planning.

♦

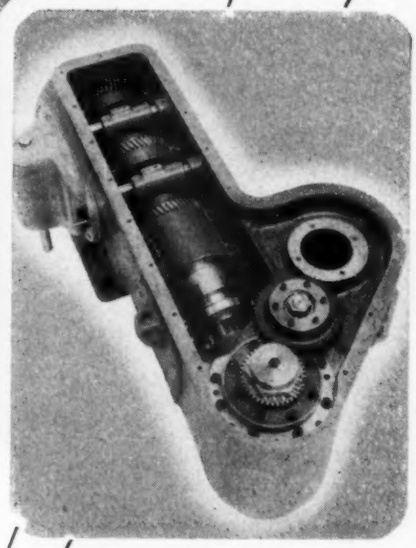
Edward F. Doty has joined the Warren Steam Pump Co. Mr. Doty was formerly with Quimby Pump Co. specializing in design and application engineering. He was the originator and developer of the modern method of computing screw capacities, friction and slippage losses in Screw and Rotex pumps.

♦

Harold Wolchonok, head of Sightmaster's television engineering department and responsible for all new Sightmaster developments during the past several years, has been engaged by Transvision Inc. to head up their research television engineering. In addition to his new duties, Mr. Wolchonok will continue on



15 TONS OF *Accuracy!*



Pratt & Whitney Model 4E Jig Borer.

Inset: View of Twin Disc MTU Duplex Clutch in the gearhead.

. . . with a Twin Disc Clutch

It takes real *precision* to locate and bore holes with an accuracy of *.0002"*. But Pratt & Whitney's new Model 4E Jig Borer does it. A 15-ton example of accuracy, stability and fine workmanship, this machine utilizes a 4½" Twin Disc MTU Duplex Clutch and brake combination in the gearhead.

Built to "wear like a bearing and perform like the best friction clutch" . . . that's the standard to which Twin Disc machine tool clutches are held. In addition to compactness, high torque capacity and long wear-life, Twin Disc Clutches feature ease of operation and single point adjustment. No wonder precision manufacturers like Pratt & Whitney think of Twin Disc when their design calls for *accuracy*.

For more information on Twin Disc Machine Tool Clutches see your nearest Twin Disc dealer or write for Bulletin No. 134-A.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

Clutches & Hydraulic Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

as Sightmaster's chief consultant and television department engineer.

♦

L. R. Ludwig has been appointed assistant to the vice president of industrial products of the Westinghouse Electric Corp.

♦

Macon Fry, Ordnance Consultant, formerly of Harrington Park, N. J., is now located in Alexandria, Va.

♦

Lyman W. Orr, George W. Patterson and **Donald L. Stevens** have joined the staff of Burroughs Adding Machine Co.'s Research Division in Philadelphia, Pa. **Alex J. Bielski** has joined the staff of the Research Division of the Burroughs Adding Machine Co. in Detroit. **Perry C. Smith** and **Thomas H. Briggs** have joined the Research Division of the Burroughs Adding Machine Co. as supervisor of the special devices department and research engineer in the special devices dept. respectively.

♦

Recently announced was the election of **Raymond R. Rausch** as vice president and executive assistant to the president of Willys-Overland Motors Inc.

♦

Lyman H. Allen Jr., formerly assistant chief design engineer in charge of chemical process design with the American Viscose Corp., has been appointed chief engineer of Foster D. Snell Inc. Mr. Allen will be in charge of supervising the design and construction of spray dryers, pilot plant operations, etc.

♦

Bernard W. Shaffer has been appointed assistant professor of mechanical engineering at the New York University College of Engineering.

♦

Malvern J. Gross, formerly vice president of the General Electric X-Ray Corporation, in charge of engineering, has been appointed administrative assistant to Dr. Kenneth H. Kingdon, technical manager of the Knolls Atomic Power Laboratory.

♦

R. H. Weigel has joined National Radiator Co., Johnstown, Pa., as a senior research engineer.

♦

Fred K. Knohl has been appointed chief engineer of Shakeproof Inc. Mr. Knohl was formerly in charge of field engineering. In his new duties he will supervise all design modifications of standard fastener products, special stampings and screw products.

♦

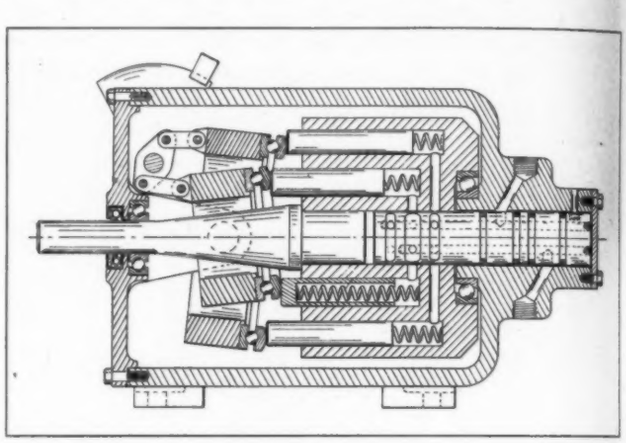
William H. Chapman has been appointed director of engineering to co-ordinate machine and product design, research and application engineering of the Hyatt Bearings Division of General Motors Corp.

♦

The American Gear Manufacturers Association has awarded the Edward P. Connell Award for 1950 to **Earle Buckingham.**

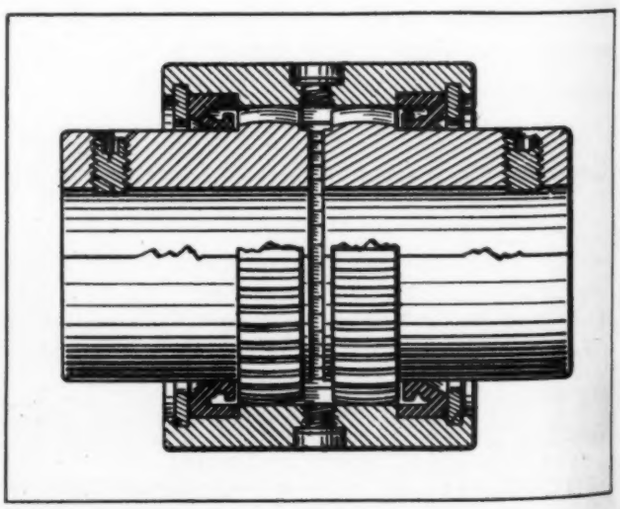
NOTEWORTHY PATENTS

BALANCED CONSTRUCTION of a swash-plate type pump or motor, using two concentric sets of axial plungers, eliminates unbalanced forces in the rotating barrel assembly. The two swash plates are 180 degrees out of phase, so that the sum of the pumping and suction forces is substantially constant

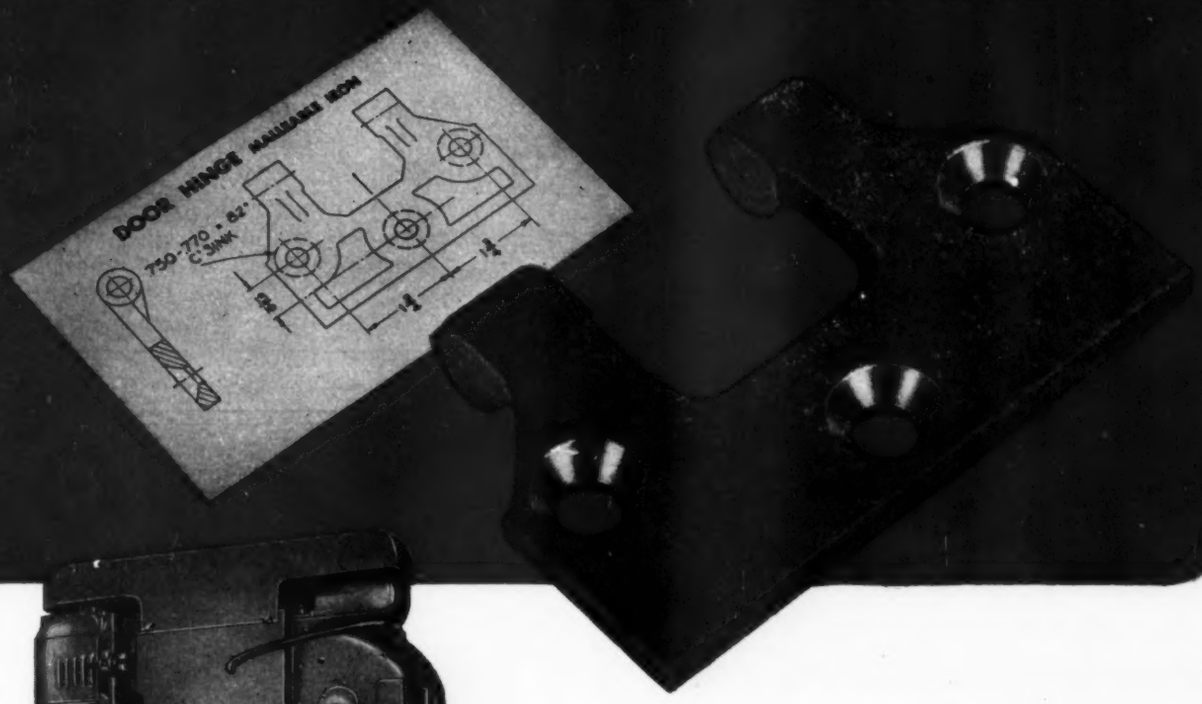


at any point around the barrel. A stationary valve, secured in the housing and projecting within the rotating barrel, is provided with drilled passages and circumferential grooves to permit continuous feeding and exhausting of the two sets of plungers. Joseph Greenhut has assigned the patent, No. 2,520,632, to The Torque Electric Manufacturing Co.

SIMPLIFIED gear type flexible coupling design, permitting straight-through broaching of the one-piece coupling sleeve instead of the usual gear cutting, is



1000 PCS. PER HOUR...



automatically fed, countersunk & ejected on this Hartford Special Automatic Drilling & Tapping Machine

Write for New Bulletin

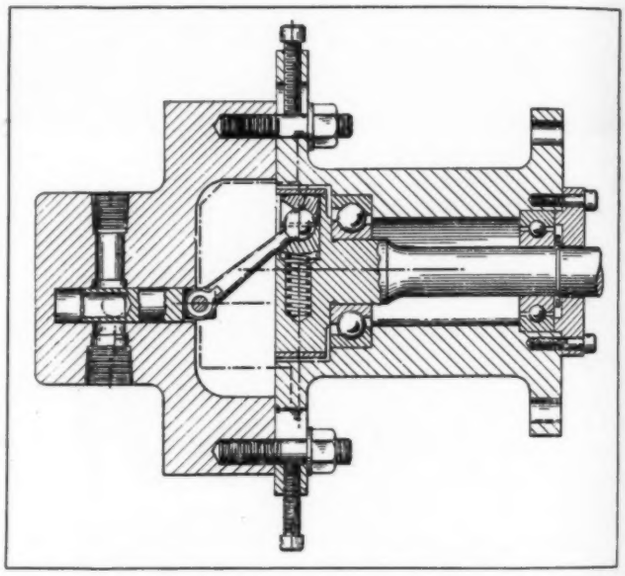
THE HARTFORD SPECIAL MACHINERY CO.

HARTFORD 5, CONNECTICUT

HARTFORD
Special
... the best buy in the long run

described in patent 2,510,414, assigned to Sier-Bath Gear and Pump Co. Inc. by Robert S. Philbrick. The single-piece sleeve eliminates complicated operations necessary in production and assembly of conventional two-part sleeves. Seal packing ring channels and retaining ring grooves are of larger diameter than the sleeve teeth root diameter, permitting the simpler broaching operation.

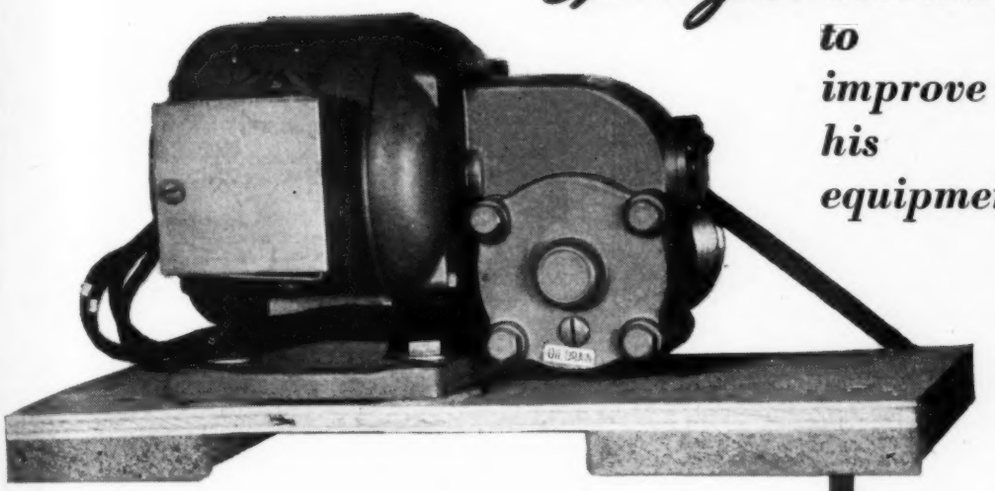
TRANSLATION OF ROTARY MOTION of a shaft-driven disk to the reciprocating pumping action of an axial plunger pump is accomplished through offset axes and a clevis and ball-and-socket mechanism as covered in patent 2,517,645. The connecting rod between plunger and disk is securely held in the disk between two spring-loaded socket members, variable reciprocating motion being imparted to the plunger



because of the offset or distance between plunger and shaft axes. A clevis joint between connecting rod and plunger causes the latter to rotate in addition to its axial movement. Grooves and porting in the plunger and its cylinder permit fluid to enter the plunger cylinder from the inlet supply line. Rotation of the plunger traps fluid in the cylinder and reciprocation of the plunger then pumps the fluid through outlet ports which open on further rotation of the plunger. Pumping capacity is adjusted by sliding the shaft housing relative to the pump body to change the offset distance between plunger and shaft axes. Carl F. Erikson has assigned the patent to Nathan Manufacturing Co.

ALIGNED OIL PASSAGES on the valve of a rotary valve type internal combustion engine provide pressure lubrication to individual bearing surfaces in controlled amounts at selected time intervals. The conical rotary valve, containing the combustion

an imaginative photographer uses Spongex® cellular rubber *to improve his equipment*



Portable motor no longer "walks" away from its job

Jack Stock's portable motor "walked" away every time he put it to work. He mounted the motor on Spongex cellular rubber—now it stays on the job. Spongex absorbs the vibrations that give legs to portable motors.

Mr. Stock is in the commercial photography business; he doesn't manufacture motors. As a neighboring businessman in Shelton, he is well acquainted with the properties of Spongex cellular rubber. Now he mounts all his motors, stationary and portable, on Spongex.

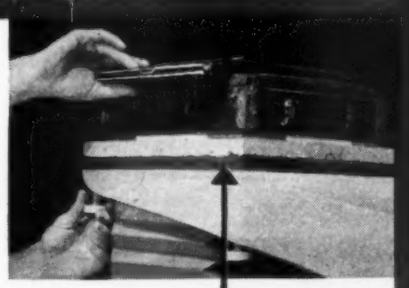
Smaller illustrations show other ways Spongex helps to produce better results in Mr. Stock's business.

If you have a vibration, insulation, cushioning, gasketing, sealing or sound damping problem, think about *Spongex*. Cellular rubber does not become a "product" until you make it one in *your* application.

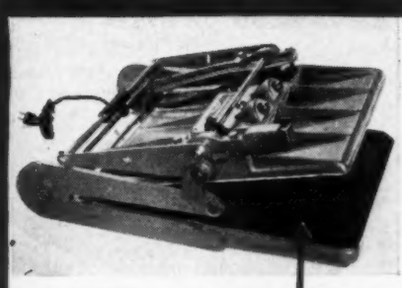
Technical Bulletin on Sponge Rubber available on request.

SRP

Uniform, dustless, printing contact
In place of felt, Mr. Stock substituted Spongex on this photograph printer. Contact on film negative is more uniform, and the tendency of felt to pick up dust is avoided.



Seal against light and dust
In installing this copy camera attachment, custom made by Mr. Stock, on top of a photograph enlarger it was essential to block out dust and light. A Spongex gasket performs perfectly.

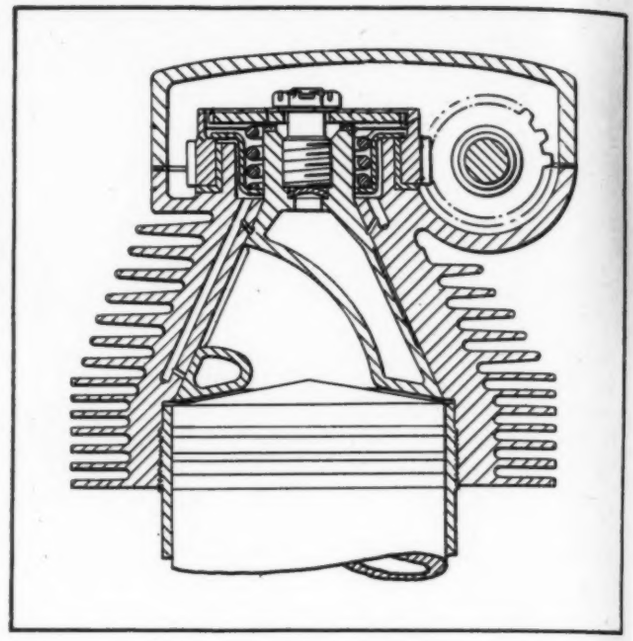


Resilient compression pad
This dry mounting press is fitted with a resilient Spongex cellular rubber base. Spongex equalizes pressure to mount photographs evenly and more securely on their backings.

The World's largest specialists in Cellular Rubber

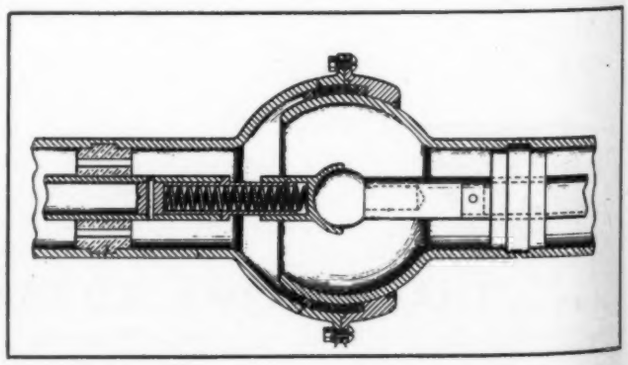
THE SPONGE RUBBER PRODUCTS COMPANY

300 Derby Place, Shelton, Conn.

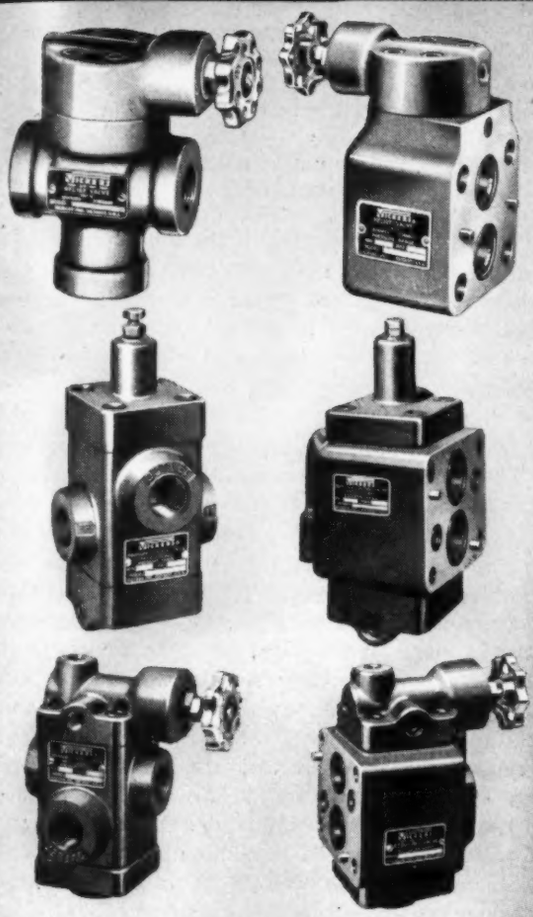


chamber, is rotated at one-half crankshaft speed through a vertical shaft and worm gearing. Lubrication is supplied to upper and lower bearing surfaces of the valve through drilled passages in the cylinder block. Oil pumped into zig-zag passages on the upper part of the valve is directed to the bearing surfaces only during the interval when sections of the grooves are aligned with passages in the cylinder block. Thus, the amount of lubrication to a particular bearing surface can be controlled by varying the length of time and number of times per revolution of the valve that the groove and outlet port, to that particular bearing, overlap. Briggs Manufacturing Co. has been assigned the patent, No. 2,516,976, by Waldo G. Gernandt.

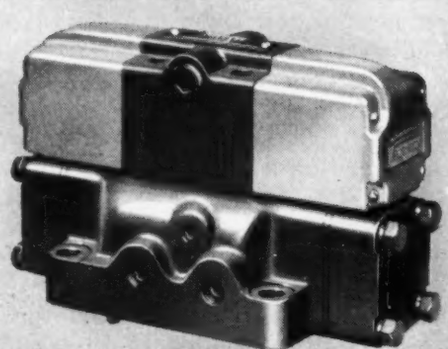
BALL-AND-SOCKET construction of a joint for coaxial cable permits swiveling about 60 degrees without introducing any electrical discontinuities in the system. The device is covered in patent 2,519,933, assigned to General Electric Co. by Charles L. Rouault. Ratio of diameters of inner and outer spherical joint members is kept equal to the ratio of inner and outer conductor diameters to maintain a constant impedance through the joint.



VICKERS PRESSURE CONTROL and DIRECTIONAL CONTROL VALVES



Vickers maximum pressure (relief) valves, pressure reducing valves, and sequence valves are constructed to limit maximum pressure adjustments within nominal working pressure range. Wires and seals can be used after final adjustment for locking.



Vickers pilot operated solenoid controlled, 2 and 3 position—4 connection type valves have oil- and water-tight solenoid enclosures and individual solenoid leads with terminals.

Give you the advantages

of J.I.C. Industrial Hydraulics Standards

The "Joint Industry Conference Hydraulics Standards for Industrial Equipment" have definite benefits for both the user and builder of machine tools and many other kinds of equipment. As these standards are directed toward assuring uninterrupted production of the machine, safety of personnel and longer equipment life (all without stifling hydraulic development), Vickers are participating in the J.I.C. program.

Shown at the left are representative Vickers Valves that comply with J.I.C. Standards. These valves embody proven design and construction features that provide dependability, greater accessibility for maintenance, simplification of piping and reduced installation costs. For further information ask for Catalog 5000.

VICKERS
Incorporated
DIVISION OF THE SPERRY CORPORATION

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

1430 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices:
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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

3558

THE ENGINEER'S LIBRARY

Electrical Engineers' Handbook
Volume II—Electric Communication and Electronics

Edited by Harold Pender, consultant, Moore School of Electrical Engineering, University of Pennsylvania, and Knox McIlwain, chief consulting engineer, Hazeltine Electronics Corp.; published by John Wiley & Sons Inc., New York; 1587 pages, 5½ by 8½ inches, clothbound; available through MACHINE DESIGN, *$8.50 postpaid.*

Seventy-eight authorities in the fields of electronics and communications have contributed to the fourth edition of this handbook to make it of reference value to designers engaged in those fields and to all designers of equipment controlled electrically or electronically.

The opening sections of the volume present tabular and graphical data on mathematics and materials. The following sections, equally replete with tabular and graphical data, cover: resistors, inductors and capacitors; electron tubes; electric circuits, lines and fields; passive circuit elements; vacuum-tube circuit elements; frequency modulation; pulse techniques; transmission circuits; electrical measurements; acoustics; electromechanical acoustic devices; optics; electro-optical devices; sound-reproduction systems; telephony; telegraphy; facsimile transmission and reception; television; electronic control equipment; aids to navigation; and medical applications of electricity.

New in this fourth edition are the discussions of frequency modulation and pulse techniques as applied to the radar and communication fields. All sections have been rewritten to be in accord with the latest developments.

Manufacturer and Association Publications

ASTM Standards: This is the 1949 edition of a triennial publication containing the formally adopted American Society of Testing Materials standards, tentative specifications, methods of tests, and definitions. This edition, which is of value to engineers concerned with purchasing, design and production, is divided into the following volumes:

Part 1—Ferrous Metals: 265 standards; 1400 pages; $10.00 each, $7.50 to members

Part 2—Nonferrous Metals: 240 standards; 1170 pages; $8.00 each, $7.50 to members

Part 3—Cementitious, Soils, Road and Waterproofing Materials: 340 standards; 1370 pages; $8.00 each, $6.00 to members

Part 4—Paint, Wood, Adhesives, Shipping Containers and Paper: 325 standards; 1320 pages; $8.00 each, $6.00 to members

Part 5—Fuels, Petroleum, Aromatic Hydrocarbons, Soap, Water and Textiles: 330 standards; 1730

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pages; $10.00 each, $7.50 to members

Part 6—Electrical Insulation, Plastics and Rubber: 240 standards; 1410 pages; $10.00 each, $7.50 to members

Each part has a detailed index and two convenient tables of contents. A complete index to ASTM standards, approximately 260 pages, is furnished to all purchasers. Copies or complete sets may be purchased from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Hydraulic Fundamentals and Industrial Hydraulic Oils: A 44-page technical bulletin covering fundamental information on hydraulic systems and selection of proper fluids. Aside from the informative, well-organized text, this edition features specially prepared phantom and cutaway drawings illustrating effectively the functioning of basic types of valves, pumps, hydraulic motors, torque convertors, etc. This bulletin, identified as B-4, is a complete revision of the former bulletin of the same number. Copies may be obtained by directing company-letterhead requests to Sun Oil Co., Philadelphia 3, Pa.

Fiberglas Bibliography: This third edition, a quick-reference guide to relevant design data, contains annotated references to 710 articles describing the development, manufacture, properties, forms and uses of Fiberglas materials. Copies may be obtained from Edward C. Ames, public relations director, Owens-Corning Fiberglas Corp., Toledo 1, O.

Design Abstracts

(*Continued from Page* 177)

obtained is as apt to hurt as to help in the presentation of the machine. Good looks should be built in and should grow with the design.

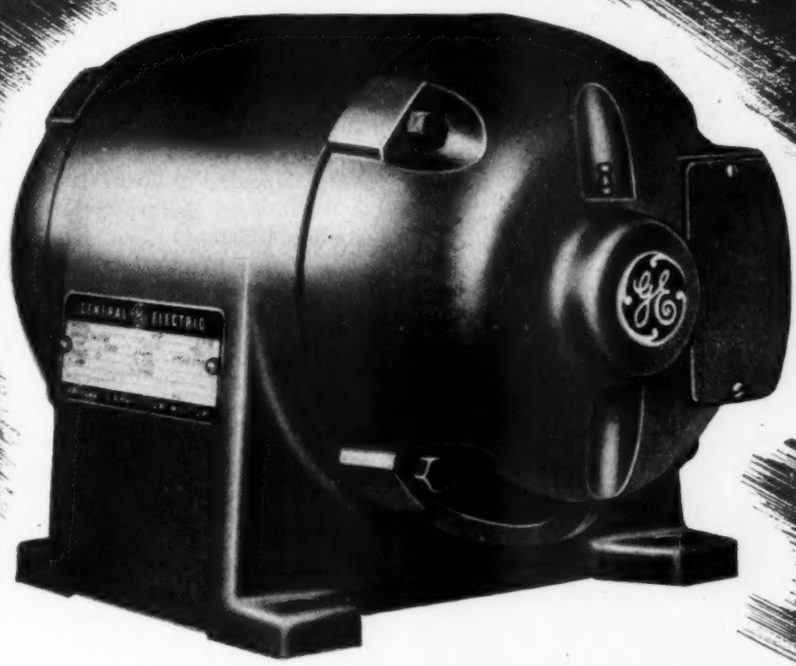
The stylist should be in close touch with the designers from the start of a design. In the early or fluid stages of a layout, there may be several possibilities in the arrangement of a mechanism and in the grouping of mechanisms to form a machine. At this time the suggestions of the stylist often can be adopted, and the planned appearance becomes an integral part of the machine.

Block Form: An expressive and useful design theme for machine tools is the "block form." It is an easy form to manipulate and is readily produced by fabrication and by casting. Square and rectilinear forms have a stable appearance and combine well with cylindrical members which are of course common in machine tools.

Edge Radii: Sharp edges where two planes intersect are not practical in castings and may look "tinny" in sheet metal or fabricated parts. In an effort to avoid sharp corners, designers are apt to go too far and, with generous radii, change a distinctive, modern design into a bulbous mass.

Corners: Die and tool charges must be kept low

Sales Getter!



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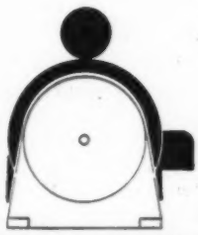
gives you these wanted features *plus* sales-stimulating eye appeal



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Factory-greased bearings hardly ever need relubrication. When they do, a pressure-relief system makes it easy.

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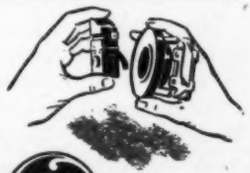

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754-3

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SINGLE-PHASE CAPACITOR MOTORS 1 to 5 hp

for machines manufactured in small lots. Since spherical corners or areas of compound curvature cannot be fabricated without dies, it is well to avoid such corners. Designs with cylindrical rather than spherical forms are readily possible.

Hiding Under a Bushel: Although the block form is useful, a designer must guard against the trend to wrap everything in rectangular packages. From long association we have learned to identify many machine members with a specific form. It is poor design to hide these well-known forms under a box. So hidden, distinctive functional mechanisms lose their identity and take on a monotonous similarity to too many products of industry. An electric motor has an easily recognized cylindrical form which through the years has evolved from the economical use of metal. Why wrap the motor up in a box or hide it under a bushel? It has a familiar, pleasing appearance; let it stand out and be recognized. Although the block form can be used effectively on machine tools it should be used with restraint.

Avoid Flutes on Large Castings

Flutes and Ribs: The beds and bases, columns and uprights of machine tools are generally made of cast iron; thus, good casting practices dictate many of the rules of styling. Flutes or ribs are not practical in large castings. An excessive amount of time is used in correcting or replacing them when they are distorted or lost in casting. Large castings are not scrapped just because an ornamental flute is imperfect. To avoid salvage work, leave flutes and ribs off large machine castings.

If ribs or flutes are to be used, they should be applied to the smaller or secondary units rather than to the main castings. On covers, plates, and doors, ribs are less likely to be deformed when molded and, if defective, the pieces can be replaced without serious loss. Ribs, especially when done in a contrasting finish, are distinctive, dignified, and in keeping with the geometric forms used on machine tools. However, it is suggested that ribs be used only if they make a positive contribution to the appearance of a machine.

Flush Type Covers: The designer will find little need for ribs and flutes if he has taken advantage of functional members of the machine as a means of providing interesting visual appeal. There is little logic in using flush type covers or compartment doors throughout the machine, with all the additional expense of manufacture and assembly, only to embellish them or other parts of the product with "speed lines" to retrieve some of the character which was so deliberately suppressed. Ease of cleaning may justify the smooth unbroken surfaces obtained with flush type covers but easy cleaning will not support the use of flutes or protruding decorations.

Expansive, unbroken, flat surfaces detract from the appearance of a machine. Since flush type covers often make large flat areas possible, they are not helpful in styling a machine. In general, a designer should try to break up large flat surfaces. A broad band or panel, elevated or relieved relative to the normal level of the surface will improve conditions

and will also assist in camouflaging any unsightly irregularities which appear in castings and which cannot be hidden by filling and painting. It is also possible to avoid flat areas by letting the encasement follow more intimately the enclosed mechanism, neither pursuing function too closely nor departing far from it.

Matching Castings: In the drive to get smooth surfaces, designers often call for matched castings so that the surfaces of two adjacent castings will appear as one. Here the designer must face reality. In practice the surfaces will not blend or match, and it is necessary to accept a noticeable and uneven intersection, or pay the serious costs of chipping and grinding. It is a much more practical approach to design for a deliberate step or break where castings meet. Casting variations will vary the height of the step but will not have a glaring effect on appearance, nor will they require added or corrective machining.

Streamlining: The purpose of getting streamline flow is to reduce resistance to motion. Thus the forms which best accomplish this have become associated with high speeds. A machine tool stays put—is often anchored to a floor of concrete—and there is no reason, why capabilities of high speed should be suggested. Occasionally one of the units on a machine tool can make valid use of streamlined forms.

Use Few Bosses and Recesses

Flat Pads: One of the most aggravating sights in machine tools is the appearance of bosses or recesses framing every screw used to fasten auxiliary parts to the machine frame. There seems to be a common belief that holes cannot be drilled into a surface unless the axis of the hole is absolutely perpendicular to the surface. Even the slightest angle or curvature of the surface provokes the use of a flat pad, elevated or depressed beyond the normal surface, as though the screw head were something sacred, to be pointed out as the most important member of the machine.

Nameplates: Nearly every machine carries some sort of nameplate or identification. It also calls for other plates with instructions for operation, patent-number plates, and much other data. Some of these markings must be made visible. They can be treated to fulfill their intended function and at the same time become an attractive accessory, instead of being a necessary evil. No portion of the machine should be converted into a signboard. The manufacturer's name should be located prominently and by itself, not forced to share attention with a long address or with a list of patent numbers.

Conclusion: The styling of a machine tool can never be expected to instill in the beholder an insatiable desire for possession. However, there is no reason why a machine should appear awkward or ugly. Appearance can be made a natural or basic part of the machine and can contribute quietly in the presentation of the machine as a precision product, a master tool created to do an exacting job quickly. Let appearance help to portray function.

From a paper presented at the ASME Fall Meeting in Worcester, Mass., September 20, 1950.

NEWS
OF MANUFACTURERS

Government officials and representatives of industry attended the formal opening of the new Harbor Island addition to the Kure Beach corrosion testing project near Wilmington, N. C., on November 15 and 16. With laboratory and exposure facilities for more than 20,000 specimens, the project is one of the largest units devoted to the study of effects of salt water and salt air on metals, alloys, nonmetallics, coatings and other materials. The project is under the direction of the **International Nickel Co. Inc.** A distinguishing feature, however, is that manufacturers regardless of competitive status freely exchange information and data. Much of the research is directed toward the solution of corrosion problems for U. S. Government service.

♦

Milwaukee Die Casting Co. is building a new plant in the 4100 block on North Holton St., Milwaukee, Wis. The new plant will contain 44,000 sq ft of floor space. A one-story structure covering 36,000 sq ft will house the production facilities; the remaining 8,000 sq ft on two levels will house the office, engineering departments, wash rooms, etc.

♦

Cornish Wire Co. Inc., manufacturer of radio, television and industrial wires, cord sets and specialty products for the communications industry, has moved to enlarged general executive offices at 50 Church St., New York 7, N. Y.

♦

Bijur Lubricating Corp. has moved its headquarters from Long Island City, N. Y., to Rochelle Park, N. J.

♦

General Electric Co. is expanding its jet engine manufacturing facilities at Lockland, O. Plans call for the procurement of additional factory space and the transfer of executive and engineering staffs from Lynn, Mass., to Lockland. Outside of these shifts, present operations at Lynn and nearby Everett, Mass., will not be changed. The additional space to be obtained at Lockland has not been decided upon. General Electric now occupies a portion of the plant at


WE
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Lockland in which Wright piston engines for aircraft were manufactured during World War II. This is leased from the Electric Auto-Lite Corp., Toledo, O.

♦

Kano Laboratories, manufacturer of lubricants, gasoline motor purges, rustproofing compounds, etc., has erected an aluminum covered plant at 1000 S. Thompson Lane, Nashville 11, Tenn. The building is approximately four times as large as Kano's former Chicago quarters.

♦

Diamond Alkali Co., Cleveland, O., has purchased the chromic acid business of **E. I. du Pont de Nemours and Co.,** Wilmington, Del. The product will continue to be produced by du Pont at its Philadelphia plant; Diamond will take over distribution on January 1, 1951. Diamond's entry into the chromic acid business represents a logical diversification of its line of chromium chemicals.

♦

Tinnerman Products Inc., Cleveland, O., manufacturer of Speed Nut fasteners, will construct a new research laboratory adjacent to its new $2,000,000 plant which was formally opened in September.

♦

Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill., has acquired all the manufacturing and sales rights to the special neon-glow indicator lights formerly made and distributed by Littelfuse Inc. The pilot type lights are designed for use on all kinds of electrically operated equipment including household and industrial appliances and radio and TV panels.

♦

The **F. J. Stokes Co.,** Philadelphia, Pa., manufacturer of industrial machinery, has begun a $700,000 expansion program designed to add one-third space to the present plant. Completion is scheduled for early 1951. Some of the additions to the plant will be a relocation of the railroad siding and enlarging of roadways, the expansion of laboratory facilities with new equipment, the installation of precision testing and inspection apparatus, and the addition of many new high-speed machine tools.

♦

Allis-Chalmers Rumley Ltd., a Canadian subsidiary of **Allis-Chalmers Mfg. Co.,** Milwaukee, Wis., has purchased the plant of the Erie Iron Works, St. Thomas, Ontario, and also an additional seven acres of land from

the city. By the first of the year, the company hopes to install machine tools for manufacturing operations; until that time, however, assembly operations will be carried out. Foremost among the products produced will be controls for diesel locomotives manufactured by the General Motors diesel plant of London, Ontario.

♦

In line with its policy of integrating all operations at its Carnegie plant, **American Cladmetals Co.,** Carnegie, Pa., is installing a thirty-inch wide cold rolling mill to be completed in 1951. Purchased from Jones & Laughlin Steel Co., the mill was in operation at that company's Otis Works, Cleveland, O. Auxiliary finishing and automatic handling equipment will be installed with the mill which was designed and built by the Mesta Machine Co.

♦

A new consulting engineering firm, **Skinner, Harlan and Ireland Inc.,** has been organized with offices and laboratory in Indianapolis, Ind. The firm will specialize in permanent magnets and soft magnetic materials and problems in allied fields.

♦

Completion of an expansion program to double production of stress-relieved silver brazing and soldering preforms for the metal working industry has been announced by the **Lucas - Milhaupt Engineering Co.,** 5057 South Lake Dr., Cudahy, Wis. The program includes the addition of specially designed equipment and an increase in production staff.

♦

Beaver Industries, 1500 W. Adams St., Chicago 7, Ill., manufacturer of screw machine products, is planning the addition of a cold-heading department. Additional equipment will be devoted to increasing the present capacity of 5,000,000 screws per month.

♦

H. K. Porter Co. Inc. has sold its locomotive business, including patterns, drawings and spare parts business, to **Davenport-Besler Corp.** (Davenport Locomotive Works), Davenport, Ia. Davenport will service all Porter locomotives now in operation as well as build duplicate locomotives including the Porter fireless locomotive.

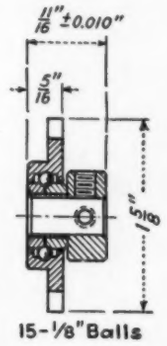
♦

General Electric Co.'s new measurements laboratory, Lynn, Mass., is in operation. Staffed by engineering specialists in magnetism, electricity, chemistry, metallurgy, sound, heat, light and color, the new laboratory

"Commercial" Ball-Bearing Data...#10 of a Series

WE WILL BE GLAD TO SEND YOU COPIES OF THE PREVIOUS ADVERTISEMENTS IN THIS SERIES.

How a special low-cost ball bearing eliminated assembly rejects

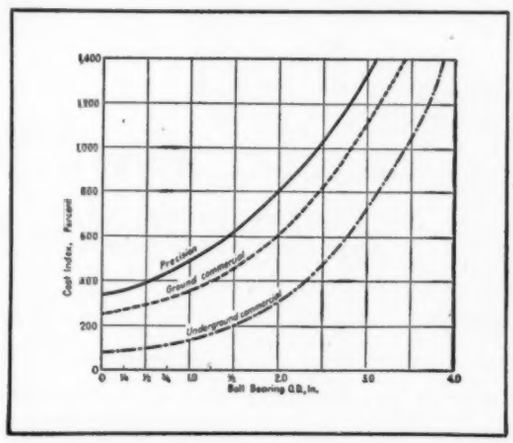


This Schatz "Commercial" Ball Bearing was specially designed to support the thread spool on a textile weaving machine operating at 2500 RPM under a 20-pound load. Previously, the spool had been held by a slotted washer, spot-welded to a standard bearing. Rejects were high, since the heat of the welding operation caused distortion of the balls and races.

Schatz engineers designed a new bearing with a split inner race and a flanged outer race to replace the washer. Result: the bearing could be used immediately without the costly spot-welding operation, and rejections due to heat distortion were completely eliminated.

Special "Commercial" Ball Bearings—like the one shown—are often less expensive than standard bearings, since costly assembly and machining time is eliminated. And many difficult anti-friction problems can be solved by various modifications in materials, inner and outer races or the ball arrangement. All "Commercials" can be furnished with single or double row of balls, felt or labyrinth seals, flanged or plain outside diameters, hardened or unhardened treads, set screws, Alemite fittings, extended inner race and hexagonal bores.

We will be glad to adapt or design a low-cost Special Ball Bearing to fit your specific job requirements.



Relative costs of precision and "Commercial" Ball bearings. In very small sizes, the cost of precision bearings *increases* as the bore decreases, due to the difficulty in maintaining close tolerances. The cost of "Commercials" *decreases* in almost direct proportion to the size.

Write for "Construction and Characteristics of Low-Cost Ball Bearings." It tells how to select low-cost Schatz "Commercial" Ball Bearings for various load and speed conditions, gives classifications of standard types for radial, thrust or combination loads, and discusses the modifications that can be made for special design, assembly or operating conditions. Ask for Catalog No. 11, too. It gives complete data on the whole "Commercial" line.

SCHATZ
"Commercial"
BALL BEARINGS

The Schatz Manufacturing Company
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contains complete facilities for applied research, product development and design in the field of measurements. The five-story, steel and concrete building has 142,000 sq ft of floor space, the major portion of which is occupied by the laboratory; the remainder, by administrative staffs of the G-E Meter and Instrument Divisions.

♦

H. K. Porter Co. Inc., Pittsburgh, Pa., has acquired Connors Steel Co. Inc., Birmingham, Ala., manufacturer of electric furnace steel and steel products. This move was made to further diversify Porter operations which already include industrial rubber products, oil well equipment, valves and air brake parts and railroad springs.

♦

The first of the nation's all-purpose synthetic rubber plants to be reactivated under the government's expanded rubber program is in production. The plant, Port Neches, Tex., was designed for a production capacity of 60,000 long tons a year. Thorough modernization by engineers of the **United States Rubber Co.** has raised the annual production capacity peak to 72,000 long tons.

♦

The New Jersey Zinc Co. has added a battery of nine new vertical retorts at its Palmerton, Pa., plant bringing the total to 43 retorts. The new retorts, which incorporate several design improvements, have approximately 25 per cent greater capacity per retort than those of the older batteries.

♦

Dow Chemical Co. has started construction on a new plant near New London, Conn., for the manufacture of Styron, a Dow plastic. The 80-acre site of the new plant is located on the Thames River and Dow plans to ship some raw materials directly from its Texas division via water route. Completion of the plant is expected within a year.

♦

Synchro-Start Products Inc., Chicago, Ill., manufacturer of automatic engine control equipment, has begun the erection of the first unit of its new factory located in the Village of Skokie, northwest of Chicago.

♦

Lenkurt Electric Co., San Carlos, Calif., has begun a construction project to add 16,000 sq ft to its plant. The company, which also has a plant in Vancouver, B. C., manufactures radio and wireline telephone and telegraph carrier equipment.

Are 10,000 pumps enough for you?

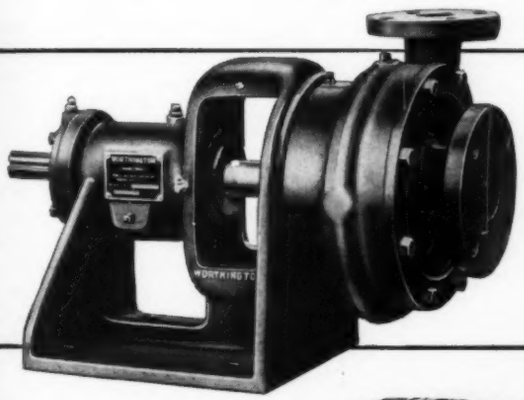
Just about. It takes that many different combinations to make sure that you—big user or small user—get exactly the right pump you need.

That's why we manufacture Worthington centrifugal pumps in over 10,000 standard combinations of capacities, heads, casings and mountings.

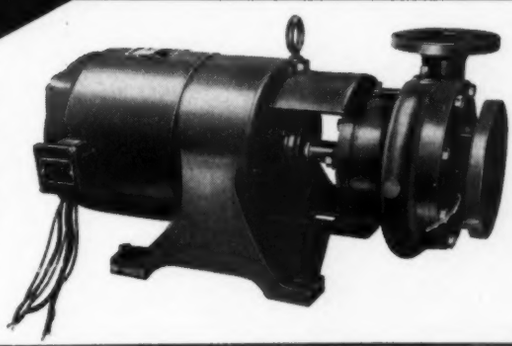
Types CN (frame-mounted) and DN (built-in motor) are made in capacities from 10 to 1800 gpm, heads to 535 ft., with 40 sizes of pump casings and 200 combinations of frame-mounted designs.

And—maximum interchangeability of parts!

Get the habit of asking for a Worthington—you'll get exactly the pump you want.



Type CN, frame-mounted, is a real "any-drive" pump—readily driven by electric motor, V-belt, or any other source of mechanical power.



Type DN is the famous Worthington Monobloc design—compact, streamlined, with built-in motor. On both types, liquid ends are interchangeable, and can be equipped with either conventional packing or mechanical seal.

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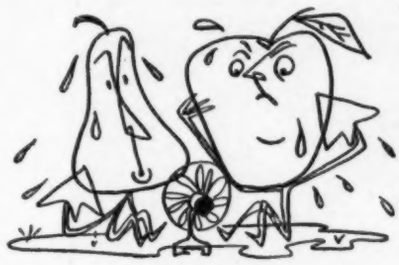
THE GOOD RIGHT HAND OF INDUSTRY

POWER TRANSMISSION: sheaves, V-belts, variable speed drives. **PUMPS:** centrifugal, power, rotary, steam. **AIR COMPRESSORS:** water-cooled, air-cooled. P.C.O.8

The Fruit Was in a Sweat



. . . and So Was the Pump

They suddenly began having a hot time of it at a fruit and produce company near the Dillon Supply Company in Raleigh, N. C.

A centrifugal pump used in their refrigeration system had called it a day, and the temperature was rising in the rooms where the produce was kept. Without refrigeration, the perishables would have indeed perished.

But a frantic call to Dillon located, in the distributor's stock of Worthington centrifugal pumps, exactly the size needed. Prompt delivery . . . and not a lettuce leaf was allowed to wilt.

It's another example of the wisdom of depending on your Worthington Distributor. No distributor offers *more* pumps . . . no distributor offers more *value* in pumps . . . than a Worthington distributor.

Worthington Pump and Machinery Corp.
Pump and Compressor Merchandising Div.
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Send latest bulletin on Worthington Centrifugal Pumps. Any other (type).....

Name.....

Company.....

Address.....

City.....State.....

SOCIETY ACTIVITIES

Several noteworthy events occurred during the **America Welding Society's** thirty-first Annual Meeting, Chicago, Ill.

Election of Officers: President—Harry W. Pierce, assistant to the president, New York Shipbuilding Corp. First Vice President—Charles H. Jennings, engineering manager, welding department, Westinghouse Electric Corp. Mr. Jennings was also selected as the 1950 Adams Lecturer, an honor awarded annually to an outstanding welding scientist or engineer. Second Vice President—Fred L. Plummer, director of engineering, Hammond Iron Works.

Lincoln Gold Medal Award: Presented to Howard S. Avery, research metallurgist, American Brake Shoe Co. This honor is awarded annually by the Society to the author of the paper adjudged the greatest original contribution to the advancement and use of welding. Mr. Avery's winning paper was entitled "Hot Hardness of Hardfacing Alloys."

Samuel Wylie Miller Memorial Medal: Presented to Dr. Wendall F. Hess, head of the department of metallurgical engineering, Rensselaer Polytechnic Institute. Dr. Hess was signaled for this honor because of his conspicuous contributions to the advancement of welding and cutting of metals.

Resistance Welder Prizes: This prize contest is sponsored by the Resistance Welder Manufacturers Associations. The more than $2000 in prizes are made through the American Welding Society. This year's awards were presented to the following: First Prize of $750 for the best paper from an industrial source to J. W. Kehoe, Westinghouse Electric Corp., for his paper "A Practical Method for Obtaining Consistent Resistance Welds."

Second Prize of $500 to three Franklin Institute engineers: A. O. Bergholm, P. W. Swartz and G. S. Hoell for their paper "Stress Distribution Around Spot Welds."

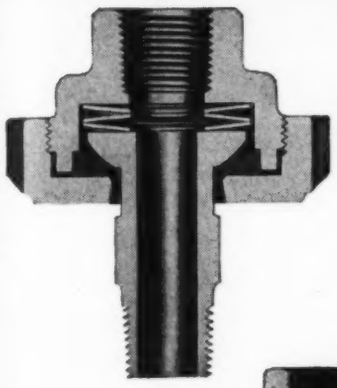
Third Prize of $250 to I. S. Goodman, Westinghouse Electric Corp., for his paper "Variables in Cross-Wire Welding of Dissimilar Metals."

For the best paper from a university source, Dr. Georges Welter, Ecole

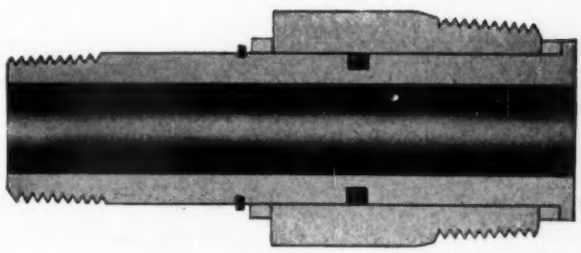
BARCO Flexible, Swivel and Revolving Joints

A complete range of design

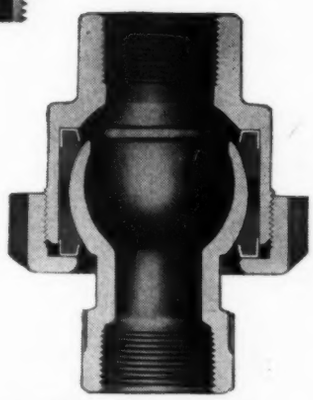
Select the one fitted to your specific needs



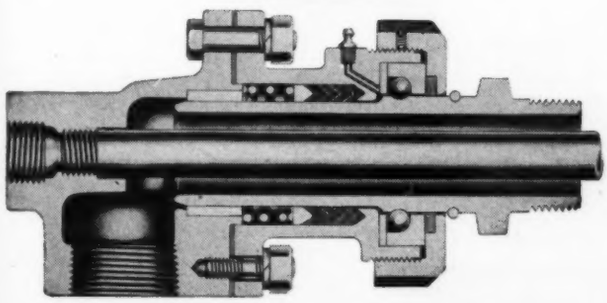
Barco Rotary Swivel Joints for use with air, oil, gas, steam, water and other fluids provide slow rotation with side flexibility.



Barco Swing Joint for hose reels, loading and unloading lines, and for tank cars and trucks—compact, inexpensive, durable.



Barco Flexible Joints for conveying oil, steam, gasoline, water, tar, corrosive acids and alkalis —where flexibility in piping is required.



Barco Revolving Joints supply steam, gas or other fluids from a fixed supply pipe to a rotating drum or member with low friction "drag." Sizes from ¼" to 5".

There is a Barco Joint for each particular problem in pipe flexibility. Different designs are available for:

- **Combined angular and swivel motion**
- **Swivel and slow rotation combined with angular motion**
- **Swing action with no side flexibility**
- **High-speed rotation**

There's a Barco Joint to handle any type of fluid with wide temperature and pressure ranges and a variety of metals and gasket materials. For more information about this *complete* line of joints, write Barco Manufacturing Company, 1806M Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal.

BARCO THE ONLY TRULY COMPLETE LINE OF FLEXIBLE, SWIVEL AND REVOLVING JOINTS

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

Polytechnique, University of Montreal, Canada, was selected the winner of the $300 first prize for his paper, "Fatigue Tests of Spot-Welded Steel Sheets." The second prize of $250 went to Dr. W. B. Kouwenhoven, The Johns Hopkins Institute and Dr. W. T. Sackett, Jr., Battelle Memorial Institute for their paper, "Electrical Resistance Offered to Nonuniform Current Flow."

♦

The **National Association of Engineering Companies** (NAEC) will hold its National Mobilization meeting, December 12, 1950, at the Detroit-Leland Hotel, Detroit, Mich. Attendance is open to representatives of any engineering company whose services include: machine and tool engineering or design; product engineering on mechanical products; or production, processes or methods engineering. In line with its basic concept which essentially is to coordinate, counsel and improve the economy of the industry it represents, NAEC is preparing a classified index of engineering services and total capacities in individual engineering companies. Such an index will facilitate the association's function as a clearing house for government agencies, contractors and industrial buyers for quickly locating needed design and engineering capacity of any type within the scope of NAEC.

♦

James C. Zeder, president of the **Society of Automotive Engineers,** announced that the Society has been called upon to assist the U. S. Armed Services with technical consulting service as it did during World Wars I and II. A recent meeting with top echelons of the services has resulted in subsequent interchanges on specific project possibilities by which SAE will provide aid and counsel.

♦

During its Annual Meeting, Nassau Tavern, Princeton, N. J., the **Society of Industrial Designers** elected Dave Chapman, Chicago industrial designer, president for the coming year. Other officers elected are: Viktor Scheckengost, Cleveland, vice president; Robert Hose, New York, secretary; and A. Baker Barnhart, New York, treasurer.

♦

The Society of Automotive Engineers' 1949 **Horning Memorial Award** will be presented to Dr. Daniel P. Barnard IV, research coordinator for the Standard Oil Co. of Indiana at the Society's 1951 Annual Meeting in Detroit. Dr. Barnard will receive the award in recognition of distin-

guished active service in the field of mutual adaptation of fuels and engines.

♦

The **Metal Treating Institute**, New Rochelle, N. Y., has begun publication of a monthly magazine, *Metal Treating*, as the official journal of the organization whose membership is composed of the leading commercial heat treating plants in the United States. The magazine is designed to be of interest to key management and operating personnel of heat treating establishments and to further the art and industry as well as to serve member companies with all news, reports of activities, technical information, etc.

♦

During its Annual Conference, Hotel Statler, New York City, the **Society for Advancement of Management** made the following awards:

Taylor Key: To Brehon Somervell (General U. S. Army, retired), chairman and president, Koppers Co. Inc. This award, named after Frederick W. Taylor, pioneer in the field of scientific management, is the highest conferred by American management. General Somervell's career is highlighted by his work in introducing engineering techniques to public administration and military services.

Human Relations Award: To Robert Wood Johnson (Brig. Gen. U. S. Army, retired), chairman of the board, Johnson & Johnson. General Johnson was chosen because of his long time leadership in the recognition of human dignity in every phase of industrial operation.

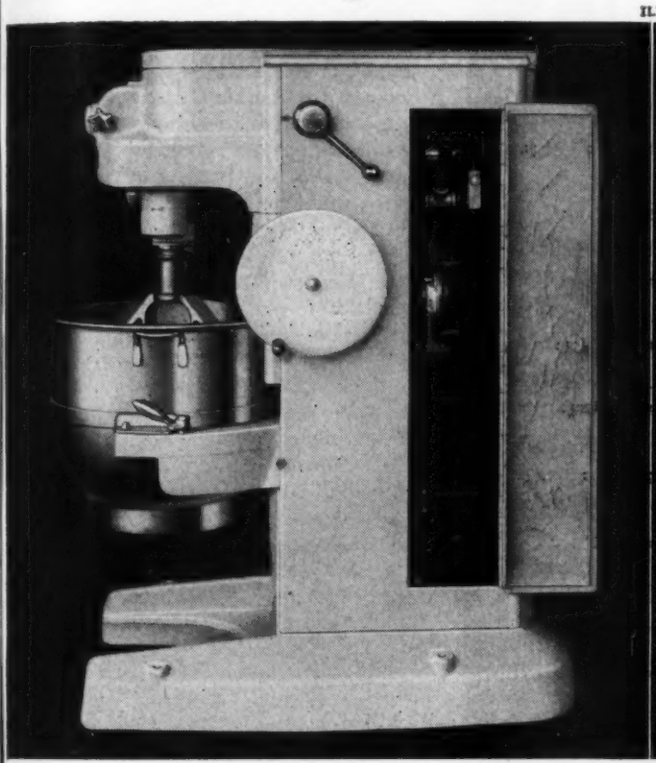
Gilbreth Medal: To Phil Carroll, industrial engineer, Maplewood, N. J. The engineer was honored for his outstanding contributions to work measurement in the field of industrial engineering. His textbooks on management controls, work standards and cost practices have contributed to the improvement of industrial working conditions.

♦

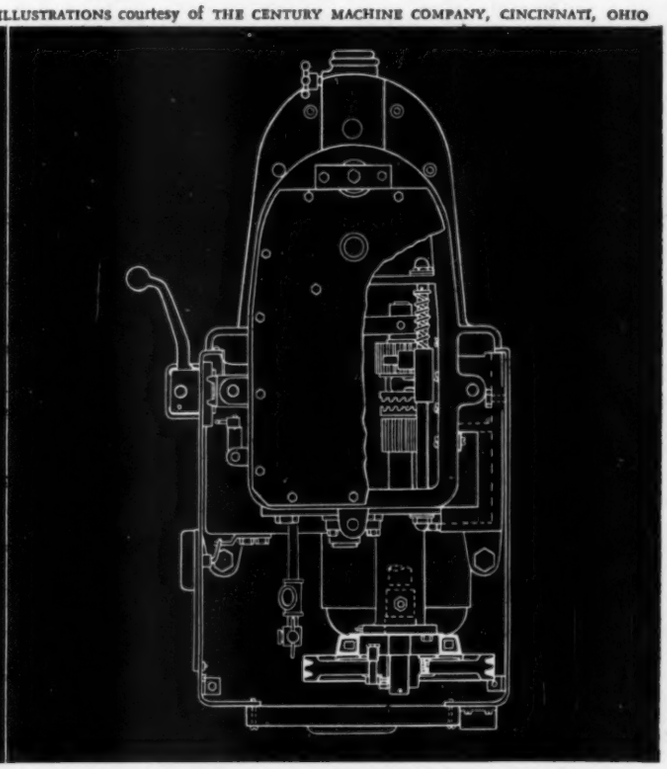
Public recognition to the three men principally responsible for the development of the Freon family of refrigerants was made by the **American Society of Refrigerating Engineers** during its 46th Annual Meeting, New York City, December 3-6. A "Certificate of Recognition" was presented to Thomas Midgley Jr., posthumously, and to Dr. Albert L. Henne and Robert R. McNary. C. F. Kettering, vice president and research consultant of General Motors Corporation who instigated the research that led to the discovery of Freon-12 as a safe refrigerant, made the awards.

How A Warner "ICB" Unit Simplifies Control on a *Century* Vertical Dough Mixer

ILLUSTRATIONS courtesy of THE CENTURY MACHINE COMPANY, CINCINNATI, OHIO



Side view of vertical dough mixer. Note position of Warner "ICB" Electric Brake Unit next to drive sheave (top right) and single control lever (top center).



Top view drawing of dough mixer showing Warner "ICB" Brake Unit mounted on drive shaft next to sheave.

What Century says About the WARNER "ICB" Unit

Using a Warner "ICB" Unit on the Century Vertical Dough Mixer gives extremely simple quick-acting control. It enables us to make a single lever do the complete job of starting, stopping and speed selection.

It also enables the use of positive tooth clutches without clashing when changing speeds. The operator has complete shifting control because the single lever simultaneously de-energizes the motor, energizes the Warner "ICB" Brake and disengages the clutch. Moving the lever to the desired speed position mechanically places the clutch teeth in position to engage. Release of lever simultaneously releases the Warner "ICB" Brake, energizes the motor and engages the clutch.

Warner "ICB" Units are electrically-powered, low-wattage clutches and brakes. They can be operated singly or in combination—automatically or by push-button control. Because they are electric—they give lightning-fast response. Because they are compact and simple, they provide easy installation and long-term dependable operation. They're a new answer to a wide variety of old machine design and operation problems. For further information on how Warner "ICB" Units may help you — write today to the WARNER ELECTRIC BRAKE & CLUTCH CO., Dept. MD, Beloit, Wisconsin.

WARNER

ICB UNIT

Warner ICB Units are manufactured by Warner Electric Brake & Clutch Co. — pioneers in the field of electric brake design and application since 1927.

SALES AND SERVICE PERSONNEL

NEWLY APPOINTED general sales manager for Carpenter Steel Co., Reading, Pa., is **H. Sturgis Potter.** He succeeds R. V. Mann, who until his recent death was vice president in charge of sales. Beginning his association with Carpenter in 1936 as sales engineer in the Indianapolis territory, Mr. Potter advanced to assistant manager of tool steel sales in the Reading office, then was named manager of tool steel sales, and in 1948 was appointed sales manager in charge of Reading mill products. His new position extends his responsibilities to the entire domestic and foreign sales organization for distribution of products from the Reading plant.

♦

B. W. Westcott has been elected vice president of Howell Electric Motors Co., Howell, Mich., and **James F. Murphy** has been appointed general sales manager. Mr. Murphy comes to Howell from the General Electric Co. and has a background of more than twenty years in the electrical and air conditioning fields.

♦

The Warner Electric Brake and Clutch Co. of Beloit, Wis., has announced the appointment of **Roger H. Brown,** Union, N. J., as eastern sales manager for the firm's ICB division. Mr. Brown formerly handled engineering sales of the company's industrial clutches and brakes in the New York area. Henceforth, New York sales will be handled by **R. C. Wiard** and **W. E. Gregg,** with headquarters at 101 South Main St., Middletown, Conn.

♦

Located in the company's main office at Sharon, Pa., **Louis K. Whitcomb** has been appointed manager of product development for Sharon Steel Corp. His duties in the newly created post will include the development of new applications for Sharon Steel products, end use products and customers' products. He will perform the same functions for Sharon's subsidiary companies. Before joining Sharon as a special representative in 1948, Mr. Whitcomb was connected with Great Lakes Steel Corp., Stran-Steel division, in Detroit as a regional sales manager and was also concerned with market development on Great

NEW PHOTOGRAPHIC MATERIALS...
NEW DRAFTING SHORT CUTS

Eliminate Costly Retracing

at INGERSOLL-RAND

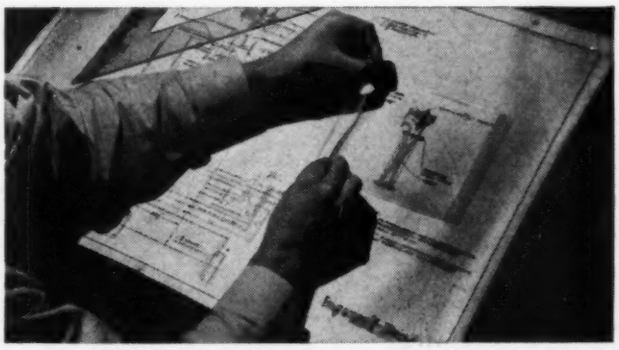
Phillipsburg, N. J.

"Ink quality" file copies of pencil drawings are produced with Kodagraph Autopositive Cloth

Instead of making expensive "ink on cloth" tracings of its original drawings, Ingersoll-Rand simply reproduces them on Kodagraph Autopositive Cloth. This new photographic material produces positive copies *directly* (like Kodagraph Autopositive Paper and Film) . . . without the negative step . . . without darkroom handling. No special equipment is required, either: a photocopy machine is used for the exposure operation . . . standard photographic solutions for development. *Result:* intermediates that have the sharpness, the sparkle of new ink tracings . . . with non-smudging, dense photographic black lines on a durable white cloth base.

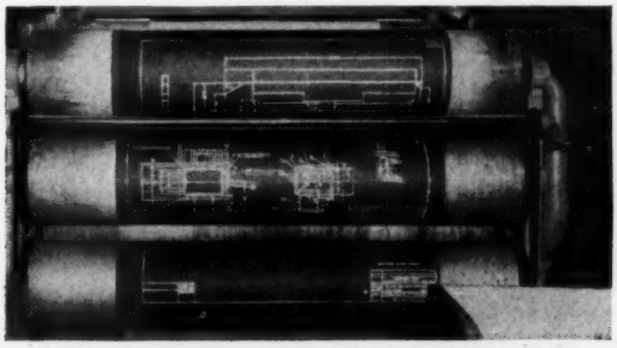
Old, soiled, or damaged drawings are restored with Kodagraph Autopositive Paper

When such drawings are taken from the files, the call is for Kodagraph Autopositive Paper—to eliminate hours of expensive retracing time. This low-cost, high-contrast photographic material increases line density . . . cleans up backgrounds . . . in many cases delivers serviceable intermediates that require no handwork at all. Drawings in very poor condition are restored by Ingersoll-Rand in the following manner: after an "Autopositive" is made, stains, creases, and other unwanted elements are removed with eradicator fluid or razor blade. Then, the print is used to produce a second "Autopositive," which is touched up with pencil if necessary.



Standard units are added to new drawings with Kodagraph Autopositive Film

Among the many ingenious drafting short cuts developed by Ingersoll-Rand is the use of Kodagraph Autopositive Film overlays made from standard-component drawings. These transparencies are kept on file . . . and taped to new drawings whenever necessary. Following this, the composite is reproduced on Autopositive Paper. *Result:* a photographic intermediate of uniform line density . . . plus important savings in drafting time.

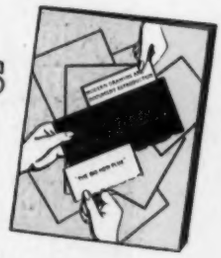


Additional advantages of using Kodagraph Autopositive intermediates

Sharper, cleaner blueprints are produced—at uniform, practical speeds—because Ingersoll-Rand makes them from "Autopositives" instead of its perishable original drawings. This way—there's far less chance of "reading errors" in the shop. And valuable originals are protected against machine wear and tear . . . constant handling; are kept safe in the files available for reference and revisions only.

Kodagraph Autopositive Materials

"The Big New Plus" in engineering drawing reproduction



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Learn in detail how you can use Kodagraph Autopositive Paper, Cloth, and Film — the revolutionary products which you, or your local blueprinter, can process quickly, economically. *Write today* for a free copy of "Modern Document and Drawing Reproduction."

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Gentlemen: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Materials.

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TRADE-MARK

Lake's Stran-Steel division products. Prior to this he was connected with Carnegie-Illinois Steel Co., first in Cleveland as a sales engineer, and later in market development work in Pittsburgh. He was in charge of all sales promotion work for end uses of steel pertaining to the building industry.

♦

Four new appointments were announced recently by the American Brake Shoe Co. **Fred P. Biggs** has been appointed president of the Brake Shoe and Castings division; **Stephen S. Conway** has been named vice president in charge of sales of the Brake Shoe and Castings and Southern Wheel division; **Ralph L. Robinson** has been made vice president of the Brake Shoe and Castings and Southern Wheel divisions; and **Edward R. Anderson** has become a vice president of the Brake Shoe and Castings division.

♦

Formerly vice president in charge of sales of Eagle Lock Co., Terryville, Conn., **Rollin B. Plumb** has joined Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y., in an executive capacity. He will play an important role in the company's sales organization, which has been greatly expanded to adequately service the demand for new product lines.

♦

In charge of tube sales to wholesalers and jobbers, **Buel A. Devine** has been appointed commodity sales manager for Wolverine Tube division of Calumet and Hecla Consolidated Copper Co. Inc.

♦

M. A. Moore, who has had engineering experience throughout the world, has been appointed sales and service representative for Double Seal Ring Co. of Fort Worth, Tex., in Maine, Vermont and New Hampshire. Mr. Moore comes to Double Seal from General Motors Corp., where he was supervisor of sales and service for General Motors diesel engines at Houston, Tex. His new headquarters are in Georgetown, Me.

♦

The Twin Disc Clutch Co., Racine, Wis., has announced the appointment of **Paul W. Wahler** as service manager and Robert A. Harmon as dealer sales supervisor. Both men will make their headquarters in Racine. Mr. Wahler first became associated with the company in 1937 as engineering assistant. In his new duties he will supervise all service operations through the five factory owned parts

stations which supply parts to all Twin Disc outlets. Mr. Harmon has been connected with sales engineering since joining the company more than three years ago.

♦

C. S. Allen has been appointed general manager of the Star-Kimble Motor division of Miehle Printing Press and Mfg. Co., Bloomfield, N. J. Mr. Allen comes to Star-Kimble from the A. O. Smith Electrical Mfg. Co. in Los Angeles, where he was vice president and general manager.

♦

Appointment of **Stuart H. Smith** as manager of industrial development and **John H. Tipton** as Cincinnati district manager of SKF Industries Inc. has been announced. At the same time, **Emerson D. Ogle,** manager of the industry division, was advanced to assistant district manager at Cincinnati and **B. K. Lathbury,** industry section supervisor, to assistant manager of industrial development.

♦

Cutler-Hammer Inc., Milwaukee, has appointed **R. A. Haworth** as manager of its Dallas, Tex., district sales office. Replacing Mr. Haworth, **M. C. Larson** has been named manager of the company's Baltimore sales office. This office will continue as part of the company's Philadelphia district sales office under **J. P. Simon,** manager.

♦

J. W. Greene, formerly sales manager of the company's New York branch, has been appointed to the newly created position of assistant manager of the valve and fitting department, Crane Co., Chicago. Mr. Greene is well qualified for this new responsibility as a result of twelve years of experience in the oil fields of the Southwest, ten years in the New York and eastern industrial markets and five years in the Midwest.

♦

In line with a general program of improving the facilities and strengthening the organization to meet continuing product demands, announcement has been made of the advancement of several sales executives of the DeVilbiss Co. of Toledo, O. **Emil F. Frey,** now in his thirty-fourth year with the sales organization of DeVilbiss, was promoted from his former post of assistant sales manager to director of sales promotion and advertising. Former assistant sales manager, **Henry M. Kidd** has become sales manager of spray equipment sales, having progressed

twenty typical GRAMIX® parts that save time, money and machining

—die pressed of powdered metal mixtures . . . oil impregnated for self-lubrication

THE UNITED STATES GRAPHITE COMPANY

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through many steps in the sales division during his sixteen years with the company. Also, **John M. Ehni**, with twenty-eight years at DeVilbiss, has assumed the joint duties of export manager and branch plant coordinator.

♦

The Bridgeport Brass Co. has announced the appointment of **E. D. (Pat) Casseday** as its Houston, Tex., district sales manager to succeed **George Chatneuff.** Mr. Casseday was recently with Bridgeport's Los Angeles office and has been connected with the copper and brass industry for the past fifteen years, with experience in both the condenser and heat exchanger field. In his new position he will be responsible for the sale of all Bridgeport products in southeastern Texas.

♦

Edward A. Livingstone, vice president in charge of sales of the Babcock & Wilcox Tube Co., Beaver Falls, Pa., has been named to the Steel Products Industry Advisory Committee to advise in the administration of the Defense Production Act as it affects the iron and steel industry. This committee was established by the National Production Authority of the U. S. Department of Commerce.

♦

The Morse Chain Co., division of Borg-Warner Corp., Ithaca, N. Y., and Detroit, has announced the appointment of **Carlton R. Becker** as western factory representative. He will supervise the sales of Morse mechanical power transmission products in the eleven states west of and including Montana, Wyoming, Colorado and New Mexico. Mr. Becker's headquarters are at 1571 Harding Ave., Pasadena 7, Calif.

♦

The Hammel-Dahl Co., Providence, R. I., manufacturer of automatic control equipment, has announced the appointment of **John O. Tragard** as vice president in charge of sales and contracts. For twenty years Mr. Tragard was sales executive and legal counsel with the Foxboro Co., and for four years was employed with the Fulton Sylphon division of Robertshaw-Fulton Controls.

♦

Shannon C. Powers has been appointed general sales manager of Russell Electric Co., 4501 South Western Blvd., Chicago 9, Ill., a subsidiary of Raytheon Mfg. Co. Mr. Powers came to the sales department of Russell Electric Co. from the apparatus department of General Electric Co.

SALES NOTES

TWO NEW appointments were recently announced by **Allis-Chalmers Mfg. Co.**, Milwaukee. The **Sales Engineering Co.**, 91 Glen St., Glens Falls, N. Y., is now a dealer for Allis-Chalmers motors and controls in Warren county, and the **Springfield Electric Service Co.**, 244 East Phelps, Springfield, Mo., has been named a certified service shop for Allis-Chalmers motors, controls and transformers in twenty southern and western Missouri counties and in five counties in northern Arkansas.

♦

The **Murray Equipment Co.**, 11820 Brush St., Detroit, Mich., has announced a distributorship agreement to handle **Worthington Pump and Machinery Corp.** Multi-V drives and fractional horsepower belts and sheaves. Murray Equipment Co. has supplied the greater Detroit area with chains, sprockets, tubing, hose and pulleys since 1946.

♦

Sales offices of the **Lapeer Mfg. Co.** have been moved from West Grand Blvd. to a new building at 1144 West Baltimore, Detroit 2, Mich. Manufacturing operations will continue at the company's plant located in Lapeer, Mich.

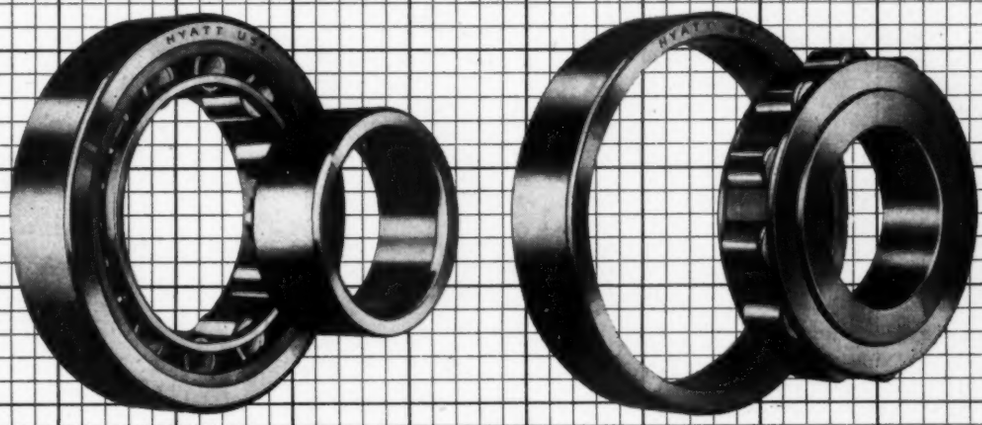
♦

Bogue Electric Mfg. Co. has announced the appointment of the **Karl Douglas Co.**, 835 West Olive St., Inglewood, Calif., as engineering and sales representative on the West Coast for 400-cycle motor-generator sets, d-c motor generators, regulated power supplies, sonic liquid-level gages for the aircraft and petroleum industries, magnetic amplifiers, voltage regulators as speed regulators, and a-c battery charg[illegible] tems.

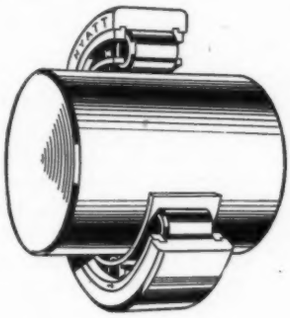
♦

An independent field [illegible]les organization has been set up by **Minneapolis-Honeywell Regulator Co.** for its valve division. The nucleus of the new organization will consist of regional sales managers and a staff of about twenty men who will concentrate on promoting the use of diaphragm control valves by instrument and original equipment manufacturers. The organization will provide national coverage. In addition, the com-

You have an option with HYATT HY-LOADS

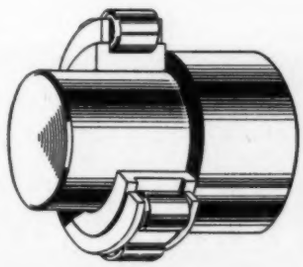


THE OPTION of omitted race operation with Hyatt Hy-Load Roller Bearings may simplify that new design you have on your drawing board.



When a shaft of larger diameter is needed for greater rigidity, or a bearing of smaller size is desired, the inner race of a separable inner race type Hyatt Hy-Load can be omitted and the rollers operated directly on a properly hardened and ground shaft.

When space is limited for the housing bore or a bearing of larger size is desired, the outer race of a separable outer race type Hyatt Hy-Load can be omitted and the rollers operated directly in a suitably hardened and ground bore.



This option you have is but one of the many features of Hyatt Hy-Loads. For complete information, write for Catalog 547, a complete engineering guide to radial bearing selection and use. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

pany will make use in some areas of field staffs now assigned to industrial, commercial and other products of various company divisions.

♦

The **Electric Products Co.** of Cleveland has appointed the **Power Equipment Co.** as representative in the western counties of Iowa and Missouri, the panhandle counties of Texas and the states of Arkansas, Oklahoma and Kansas. With offices in Kansas City, Mo., the Power Equipment Co. will handle all the industrial lines of the Electric Products Co.

♦

The **Hobsite Products Co. Inc.** of Paterson, N. J., manufacturer of Keldur, vibration isolation sheet material, has moved its principal offices to 308 Sussex St., Harrison, N. J., where greater facilities are available for service and customers' inquiries.

♦

Removal of its general sales office to 11 Commerce St., Newark 2, N. J., has been announced by **Volco Brass & Copper Co.** of Kenilworth, N. J. The move was designed to accommodate the expanded operations of the company, as well as to facilitate customer contact. Volco will continue to maintain administrative offices and mill operation in Kenilworth.

♦

The **Work-Factor Co.**, 366 Madison Ave., New York, N. Y., management consultants, has appointed the **Dill, Clitherow Co.** of Chicago as sales and service representative for clients in Illinois, Wisconsin and Indiana who use the Work-Factor system of time study in industrial production.

♦

The **Westcott Chuck Co.**, Oneida, N. Y., has appointed **John T. Everett & Co.**, 606 M & M Bldg., Memphis, Tenn., district representative of the company in Alabama, Arkansas, Oklahoma, Louisiana, Mississippi and Texas.

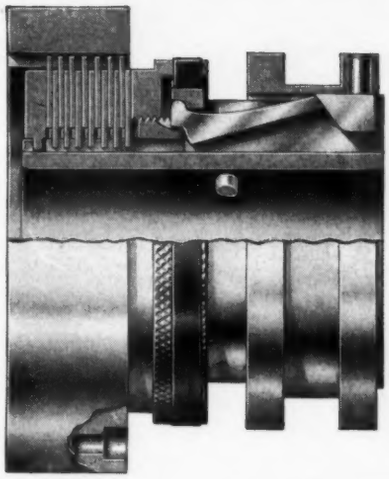
♦

The purchase of **Plastic Molders Inc.** of Chicago by **P. R. Mallory & Co. Inc.** has been announced. The company will henceforth be known as **P. R. Mallory Plastics Inc.**, 3670 Milwaukee Ave., Chicago 41, Ill. Facilities and operating personnel will remain unchanged in the company's production of compression and injection molded plastics.

♦

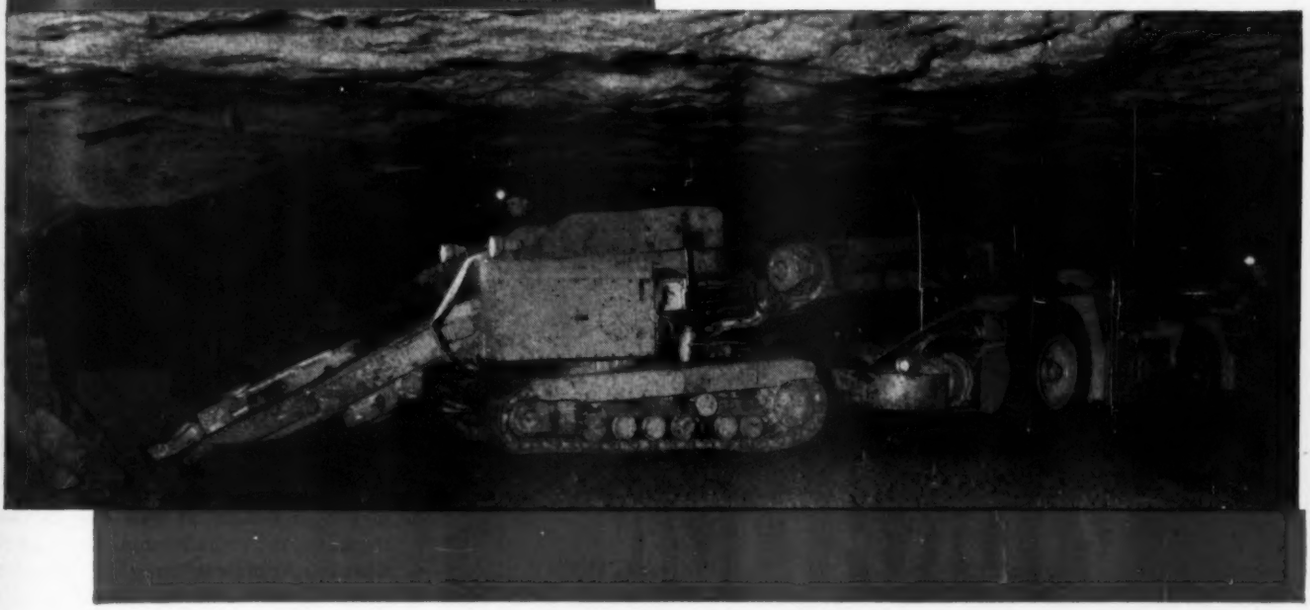
Pneu-trol Devices Inc., has moved to a new office and factory, 1436 North Keating, Chicago 51, Ill.

MAXITORQ



Keeps Good Company . . . .

in the **MINING FIELD**



We are pleased this month to pay tribute to the Joy Mfg. Co., Pittsburgh, Pa., for its remarkable 18-HR-2 Rock and Ore Loader . . . and to express our gratification for their selection of Maxitorq Clutches as original equipment.

Two double No. 27 Maxitorq floating disc Clutches . . . one for each crawler tread . . . control the power for independent forward and backward movement that permits precision maneuvering and positioning of the loader.

Only a ruggedly-built clutch can stand up under the tough going of this "battleship" machine that loads up to *12 tons of ore per minute.* Maxitorq is taking the job in its stride.

If you have a tough job requiring positive clutch action and long life . . . or an application calling for overload protection of a shear pin nature . . . ask our engineers for practical recommendations. Within its capacity (to 15 H.P. at 100 r.p.m.) there's no finer clutch made.

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9CJ50

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MEETINGS AND EXPOSITIONS

Jan. 8-12—

Society of Automotive Engineers. Annual meeting and engineering display to be held at the Book-Cadillac Hotel, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Jan. 15-18—

Plant Maintenance Show to be held in the Public Auditorium, Cleveland. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 18-20—

Society of Plastics Engineers. Seventh annual national technical conference to be held at the Hotel Statler, New York. Additional information may be obtained from society headquarters, 409 Security Bank Bldg., Athens, Ohio.

Jan. 22-26—

American Society of Heating and Ventilating Engineers. Tenth international heating and ventilating exposition to be held at the Commercial Museum in Philadelphia, Pa. Additional information may be obtained from the International Exposition Co., 480 Lexington Ave., New York, N. Y. Charles F. Roth is manager.

Jan. 22-26—

American Institute of Electrical Engineers. Winter meeting to be held at the Statler Hotel, New York. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

Jan. 29-Feb.1—

Institute of the Aeronautical Sciences. Nineteenth annual meeting to be held at the Hotel Astor, New York. R. R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

March 6-8—

Society of Automotive Engineers. Passenger car, body and materials meeting to be held at the Book-Cadillac Hotel, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

motors that add impressive Selling Points to the product — and please the End-User

- ☑ **100% TOTALLY ENCLOSED.** Baldor Streamcooled Motors are completely enclosed and fully protected against internal damage. They're dust-proof, drip-proof and vermin-proof.
- ☑ **COOL-RUNNING.** An outer-mounted fan forces cooling air over the entire exterior of the motor.
- ☑ **NON-CLOGGING.** These motors cannot inhale dust, dirt, lint or other contamination. There is no air-passageway to clog up and cause burnout or lowered efficiency. No dismantling for cleaning—no interruption of production.
- ☑ **QUIET, SMOOTH OPERATION.** Baldor Motors are of perfectly balanced design which assures quiet, smooth operation.
- ☑ **CLASS A or B INSULATION.** All Baldor Motors are of ball-bearing construction and are furnished with either Class A or B insulation.
- ☑ **INDIVIDUALLY TESTED.** Each motor receives a thorough commercial test before leaving the plant.
- ☑ **NATIONALLY SERVICED.** Baldor Motors are sold and serviced in more than 200 Trade Centers.

BALDOR ELECTRIC COMPANY

ST. LOUIS and other Principal Cities

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MOTOR SPECIALISTS 29 YEARS

NEW MACHINES

And the Companies Behind Them

Domestic

VACUUM CLEANER: Medium-priced AVT-811 model tank type unit with throw-away dust and dirt collector bag. Controlled by foot switch. Finished in gray with chrome trim. Dimensions, 23 in. long, 7⅞ in. wide. Weight, 15 lb. *General Electric Co., Bridgeport, Conn.*

Heating and Ventilating

PORTABLE HUMIDIFIER: Evaporates ½ to 2½ pints of water per hour. Air output 12,000 cu ft per hour. Measures 14½ by 12½ by 11½ in., weighs 19 lb. *Kauffman Air Conditioning Co., St. Louis, Mo.*

ELECTRIC BATHROOM HEATERS: Heat by radiation and convection. Available in 1250 and 1500-watt sizes having 4266 and 5120 Btu per hour output ratings, respectively. Wall opening required, 17¾ in. high, 8¼ in. wide, 4 in. deep. *Westinghouse Electric Corp., Pittsburgh, Pa.*

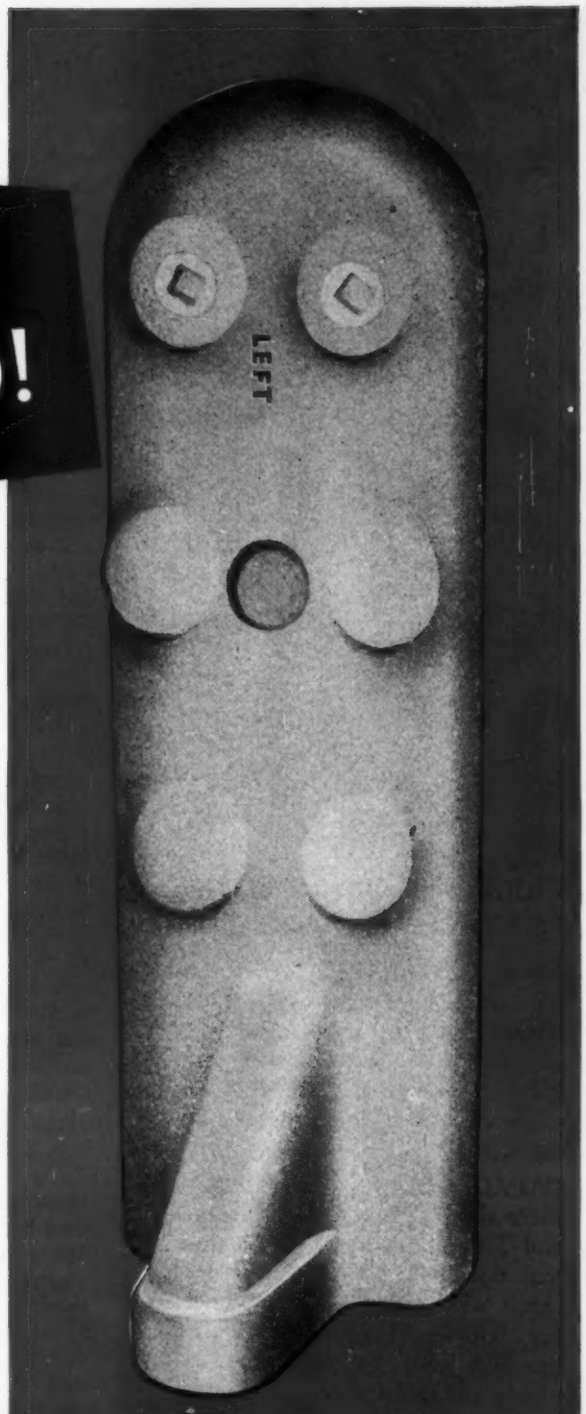
HEAT TRANSFER UNIT: For dissipating heat from power tubes or condensers in radio, television, radar, communications or other apparatus. Model 20-X unit dissipates to 15,000 watts by circulating cooling medium through system. Equipped with 6-bank reverse-flow radiator, squirrel-cage blower with 1400 cfm capacity, 3-stage centrifugal pump, expansion tank and necessary fittings. Enclosed in steel cabinet with choice of finishes. *Eastern Industries Inc., New Haven, Conn.*

Heat Treating

INDUSTRIAL CHILLING UNIT: Sub-Zero model R-120 for heavy duty at minus 120 F. Ten cu ft chilling chamber refrigerated by two units in cascade relationship. Has thermal capacity of 2000 Btu per hour at minus 120 F. For complete stabilization of metals, heat treatment of steel, shrink fit work, testing, etc. Chilling chamber measures 18 by 30 by 33 in. Insulated with 4 in. of Santocal. *Sub-Zero Products Div., Deepfreeze Distributing Corp., Cincinnati, O.*

SINTERING FURNACE: Molybdenum-vacuum furnace with max temperature 3300 F. Electric unit has neutral to reducing atmosphere pure enough to sinter chromium without oxidation. Steel case maintains 30-in. mercury vacuum. Tube has working area of 2 in. ID by 28 in.

THIS CASTING SAVED $12,000.00!



Why an Electrode Holder, redesigned by National Bearing Division, lasted over 73 times longer

A large Midwest plant was getting 5 days service from furnace electrode holders . . . before a trial order was placed with National Bearing Division. This plant saved dollars—*right from the start.* A special copper alloy permitted sound, dense castings at no sacrifice in electrical conductivity. Result? *30 days service—instead of 5—before replacement.*

On the next order, National Bearing Division engineers submitted a new design for the clamp—for greater strength and resistance to cracking. The redesigned electrode holders are still in use—after a year of trouble-free operation! They've saved $12,000.00 on replacement costs and furnace maintenance.

Better, longer-lasting non-ferrous parts can save money in your plant or product . . .

National Bearing Division has complete facilities for finding practical, economical solutions to non-ferrous bearing and casting problems. Investigate these complete facilities—whether your problem requires designed engineering service, or production of non-ferrous parts to your own specifications.

If you design, specify or purchase . . . This catalog will interest you

Find out how complete facilities for Research, Engineering and Production can reduce costs of non-ferrous parts in your plant or product. Write for a free copy of this catalog.

NBM

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4931 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

long, with 18 in. controlled temperature length. Cylindrical furnace may be rotated for operation in horizontal or vertical position. Power input, 6 kw, 220 volt, 60 cycle, single phase. *Pereny Equipment Co., Columbus, O.*

Maintenance

PORTABLE STEAM CLEANER: Electric unit for cleaning machinery, equipment or facilities. Model JC-20 uses steam jet from built-in high-pressure boiler. Rated at 20 kw max, unit available for 220, 440 or 550-volt operation. Dimensions, 16 in. wide, 40 in. long. *Livingstone Engineering Co., Worcester, Mass.*

AIR HAMMER: For drilling, chipping, trimming, riveting, etc. Has no recoil or kick, operates only when in contact with work. Impact force adjustable. Measures 9½ in. overall with 1-in. diameter piston, requires 30 to 100 psi air supply. *Burgess Thomas Co., Bloomfield, N. J.*

Manufacturing

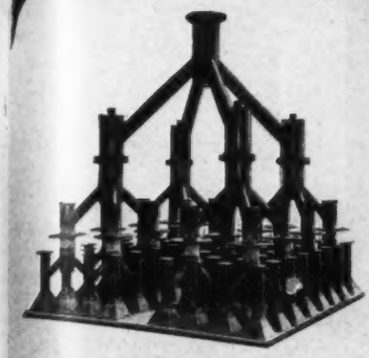
AUTOMATIC PRESSES: Wide-bed presses ranging from 30 to 2500 tons capacity. Include T-slots in top platen, remote control of variable-speed drive. Die clearance in 175-ton model, 28 in. front-to-back, 60 in. left-to-right. Roll feeds have 3-in. vertical adjustment, take material to 18 in. wide. Pitch adjustment of roll feeds, 0 to 12 in. Max stroke in 175-ton model, 10 in. Max speed, 250 strokes per minute depending on stroke length. *Brandes Press Co. Cleveland, O.*

INJECTION MOLDER: For plastic injection molding of buttons, dentures, die tryout work, or other pieces to ¾-oz. Model HC-75 self-contained, uses hydraulic system for injection. Mechanical toggle clamp provides clamping pressure. Handles all thermoplastics, can be converted to nylon. Injects 0.44 cu in. material per second with ¾-in. diameter ram. Plasticizing capacity, 5.5 lb per hour. Max pressure on oil, 1200 psi; max pressure on material, 8600 lb. Mold size, 6 by 5 by 5 in., max casting area, 6 sq in. *Moslo Machinery Co., Cleveland, O.*

BENCH GRINDER: Portable Model 400 grinder uses two 4-in. diameter, ½-in. face vitrified grinding wheels. Has fan-cooled, 110-v, single-phase 3500-rpm motor and two adjustable tool rests. *Portable Electric Tools Inc., Chicago, Ill.*

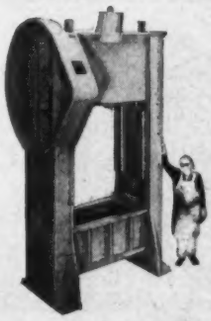
INCLINABLE PRESS: Single-stroke No. 1½ press with 15-ton capacity. Open back model has 2-in. stroke standard, with up to 3-in. stroke available. Powered by ¾-hp, 1140-rpm motor through 160 rpm flywheel. Bolster area, 10 by 14⅜ in.; throat

Steel-Weld FABRICATION

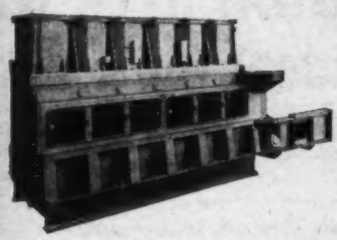


One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.

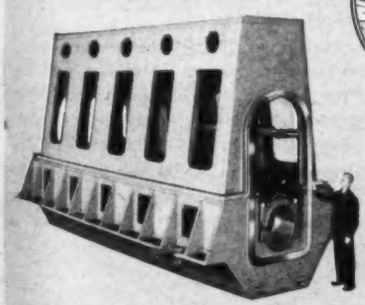
Pressure Vessels for the Chemical and Allied Industries.



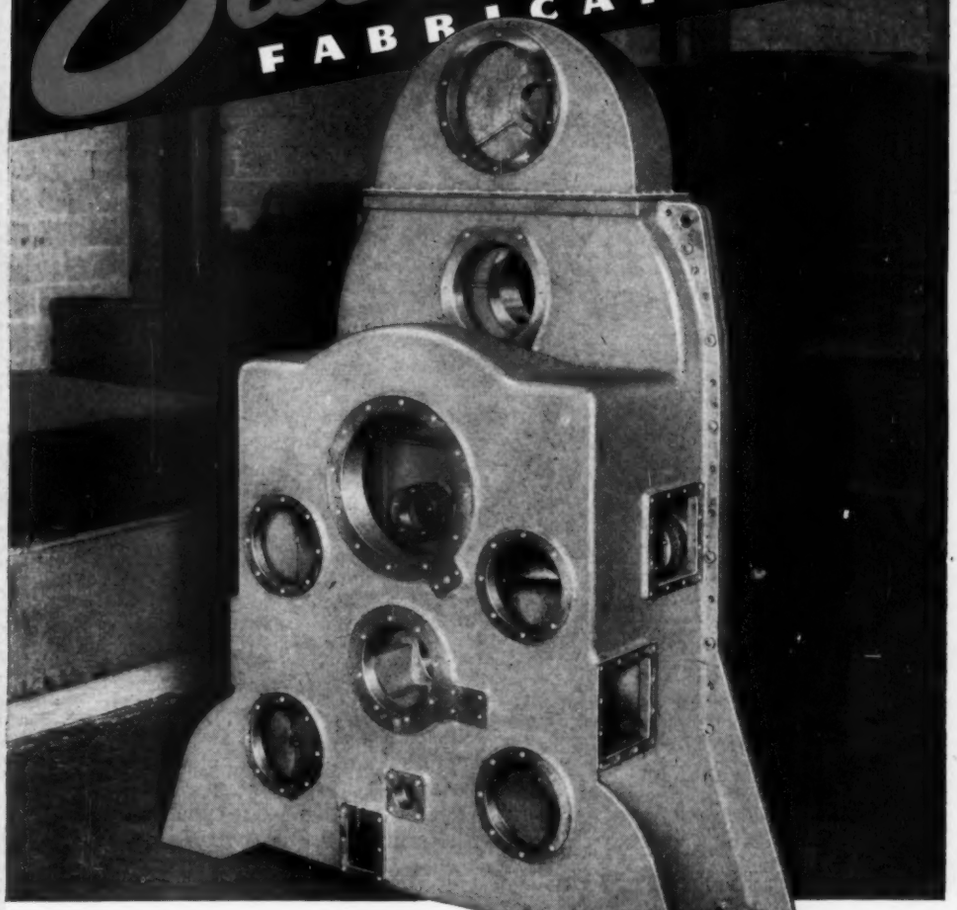
Heavy Press and Machine Frames and Bases for the Machine Tool Industry.



Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.



Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.



A Steel-Weld Fabricated Gear Housing produced and completely machined ready for assembly by the Steel-Weld Division of The R. C. Mahon Company.

More and more designers are taking advantage of the many savings made possible by today's advanced technique in Steel-Weld Fabrication . . . thousands of heavy machinery parts and major assemblies are now produced in this form for manufacturers in many fields. If you can use Steel-Weld Fabrication to advantage, you will find in the Mahon Company an unusual source for welded steel in any form . . . a source with complete, modern fabricating and machining facilities backed by a staff of design engineers and craftsmen from whom you may expect a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

depth, 5½ in.; bolster to slide distance, 6¾ in. Weighs 1100 lb, less motor. *Sales Service Machine Tool Co., St. Paul, Minn.*

VOLTAGE REGULATORS: Redesigned MLT 32-step regulators providing three-phase regulation in ⅝-per cent steps. Ratings increased to include 2500-kva, 69,000-volt size. Includes new voltage regulating relay which is permanently adjusted at factory, line-drop compensator with continuously variable resistance and reactance components, and relay adjusting rheostat. *Transformer and Allied Products Div., General Electric Co., Schenectady, N. Y.*

BENCH GRINDER: For grinding and lapping with silicon carbide or diamond abrasive wheels. Features 1-hp reversible motor, 12 gph impeller type coolant pump, swiveling wheel guard, three-position table to provide for wheel wear, milled protractor slot, and coolant filter. *Wickman Manufacturing Co., Detroit, Mich.*

METAL CUTTING SAW: Will also perform milling and planing operations such as slotting, removing corners of die blocks, etc. Machine raises and lowers hydraulically. Capacity, 14 by 18 in.; clearance under blade, 20 in.; cutting speeds, 60, 90 and 120 fpm. Vise swivels 45 degrees in either direction. Stock stop automatically moves out and up at end of cut to eliminate binding of blade. Automatic vise control available to eliminate hand tightening and loosening of vise when duplicate cuts are to be made. *W. F. Wells & Sons, Three Rivers, Mich.*

TABLETTING PRESS: For molding tablets and cakes or for pressing of ceramic and powder metal parts to 1¼ in. diameter. Model F-4 press applies 4 tons pressure from above and below. Production rate, 50 per minute. Speed adjustable by handwheel while press is running. Adjustment for change in part thickness made by controls at front of press. *F. J. Stokes Machine Co., Philadelphia, Pa.*

LINE BORING MACHINE: For simultaneous boring of crankshaft and camshaft bearings in automotive engine blocks. Operator loads blocks in machine, presses cycle start button, and removes blocks after boring. Production capacity, 25 to 35 blocks per hr. *Ex-Cell-O Corp., Detroit, Mich.*

BENCH GRINDERS: Line of four grinders for garages, repair shops, metal working plants, etc. Line includes: 6-in., close coupled, ¼-hp model with ½-in. wide wheel; 6-in. long end bell, ¼-hp model with ¾-

ROCKRITE TUBING

Has High Surface Finish

BEFORE MACHINING!

PROVED BY PROFILOMETER RATINGS AS LOW AS 5 MICROINCHES

You can trim machining costs of ring shaped and cylindrical parts with Rockrite Tubing because it reaches your plant with close tolerances and smooth surfaces. The reason? This tubing is sized by a distinctively different process:

- **Dies compress the metal against a mandrel, tending to iron out small irregularities on both the inside and outside surfaces. The metal flows from high spots in the same manner as when it is forged.**
- **A certain amount of planishing action also takes place on the inside surface of the tube as it elongates under the pressure of the dies and creeps forward while in contact with the mandrel.**
- **In no part of this operation is there any action which can produce longitudinal scratches. The metal is not drawn through a die and over a mandrel.**

The proof of high surface finish? Profilometer readings recently taken on samples of Rockrite Tubing exhibiting superior finish show a range of RMS values of 5 to 55 microinches. In the manufacture of parts such as hydraulic cylinders this superior finish means substantial cost-savings well worth investigating.

HOW DO YOU SCORE? Do you know the three requirements essential for tube accuracy and lower-cost machined parts? New bulletin tells answers . . . gives more facts and figures on close-tolerance Rockrite Tubing. Send for your copy today.

ROCKRITE TUBING

ROCKRITE saves more than any other tubing

- **Higher cutting speeds**
- **Tools last longer between grinds**
- **Work-surface finishes are better**
- **Machined parts have closer tolerances**
- **Stations on automatics are often released for additional operations**
- **Extra-long pieces available—less downtime for magazine stocking and fewer scrap ends**
- **Closer tolerances often eliminate necessity for machining on outside or inside**

TR-118

TUBE REDUCING CORPORATION · WALLINGTON, NEW JERSEY

in. wide wheel; 6-in., long end bell, 1/3-hp model using ¾-in. wide wheel; and 8-in., long end bell, ¾-hp model using 1-in. wide wheel. Wheel speed, 3440 rpm. *Cummins Portable Tools, Div. of Cummins Business Machines Corp., Chicago, Ill.*

DC WELDERS: Selenium rectifier welders with dual welding circuits. In 300/600 and 400/800-amp sizes. Dual circuits may be used independently or in parallel to provide single circuit of twice capacity. Parallel operation for max capacity obtained by bridle across secondary output terminals. *Westinghouse Electric Corp., Pittsburgh, Pa.*

SURFACE FINISHER: Special-purpose single-spindle machine equipped for mechanical or magnetic holding. For applications requiring precision grind operation such as pliers, wrenches, iron sole plates, springs, etc. Actuated by electro-hydraulic system, with 40-in. wide roll mounted on spindle. In and out stroke adjustable from 0 to 24 in. Max holding and working area, 24 by 38 in. Air circuit provides float of buff at predetermined uniform pressure. *Clair Manufacturing Co., Olean, N. Y.*

TRANSFORMER WELDER: Model MCX 200-amp arc welder for sheet metal and industrial jobs. Dimensions, 12 by 17 by 23 in. Three current ranges selected by tapered plug connectors. Infinite hand crank adjustments within each range provide 30 to 250 amp currents. Can use $\frac{1}{16}$ to $\frac{5}{32}$-in. diameter electrodes. Employs hot start control with hermetically-sealed gas-filled time-delay relay magnetic switch with no open contact. *Air Reduction Sales Co., New York, N. Y.*

VERTICAL MILLING AND DIESINKING MACHINE: Sensitive ¾-hp machine with 10 spindle speeds. Overall table dimensions, 25¼ by 9⅜ in., max spindle to table distance, 17¼ in. Headstock swivels 90 degrees. Provision made on headstock for installing tracer arm for duplicating work. Longitudinal hand movement of table, 12¾ in.; cross movement of table, 8 in.; vertical movement of table, 17¼ in., floor space required, 56 by 56 in.; net weight, 1650 lb. *DCMT Sales Corp., New York, N. Y.*

SPECIAL STITCH WELDER: For welding spouts to stainless coffee pots. Adaptable to permit spot spacing and electrode positioning on other curved surfaces with minor gear and cam alterations. Spot spacing, work indexing and electrode operation automatically controlled. Machine rated at 30 kva, welds 0.032-

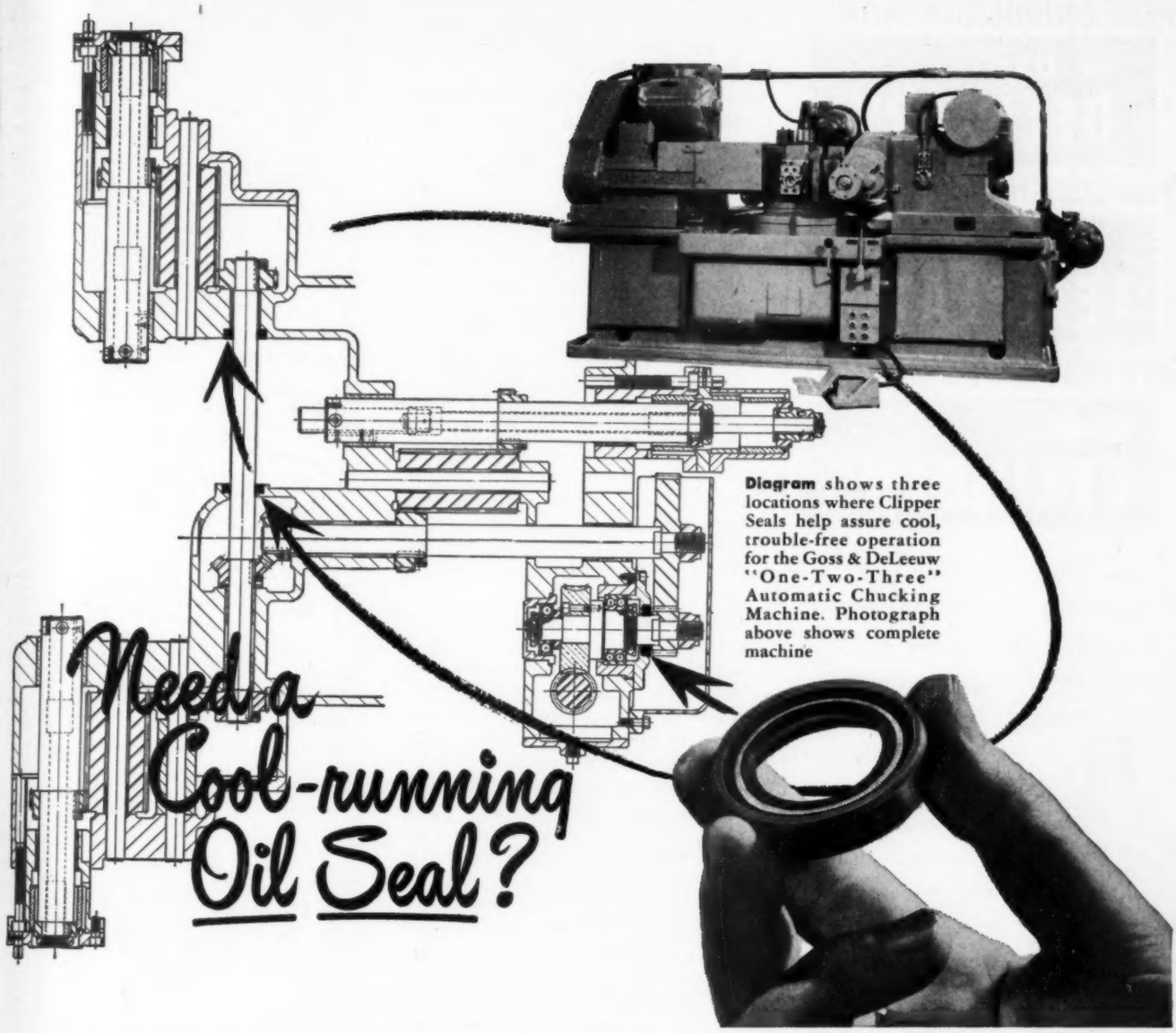


Diagram shows three locations where Clipper Seals help assure cool, trouble-free operation for the Goss & DeLeeuw "One-Two-Three" Automatic Chucking Machine. Photograph above shows complete machine

Need a Cool-running Oil Seal?

Goss & DeLeeuw turns to Clipper Seals

IF YOU'RE SEARCHING for an oil seal that you can depend on to run cool... thereby minimize friction and shaft wear, and last longer . . . you'll be interested in hearing why The Goss & DeLeeuw Machine Company selected Clipper Seals for their "One-Two-Three" Automatic Chucking Machine.

The "One-Two-Three"—a revolutionary contribution to the metal working field which permits machining three-faced parts in a single operation—required an oil seal that would minimize friction and wear at high shaft speeds. It would also have to do a highly efficient job of keeping lubricants in place.

After careful tests, Goss & DeLeeuw found that the simple design of the Clipper Seal decidedly reduces friction and wear . . . assuring cool, trouble-free operation plus a long service life. They found, too, that Clipper Seal's tough, dense heel gives the rigidity necessary for a press fit in the cavity . . . while the flexible lip, held in light but positive contact with the shaft by a specially designed garter spring, provides effective sealing at all times.

The solution to *your* sealing problem may be this all-round efficiency of Clipper Seals. They come in a variety of precision-moulded designs . . . in sizes to fit shaft diameters from ¼" to 66", for temperatures to 450F, and for shaft speeds to 3500 rpm. Get complete information by writing for Brochure PK-46A. Address Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

in. to 0.022-in. 18-8 stainless at rate of 192 assemblies per hour at 80 per cent efficiency. *Taylor-Winfield Corp., Warren, O.*

TUBE BENDER: Makes up to 1000 bends per hour on 1-in. 16-gage steel tubing. Fully automatic die and clamping head grips and bends tube automatically. Handles round, square and rectangular tubing and pipe, light angles, channels, solid bars, etc. Interchangeable dies available for different size tubing diameters and radii. *Paul Machine Tool & Die Works, Chicago, Ill.*

BAND SAW BLADE WELDER: Handles new 0.050-in. diameter contour-cutting band saw blade and all types of blades to ½-in. flat. Particularly useful on internal tool and die work. Fully automatic unit has built-in grinder and gage for checking thickness of weld on flat saws. Overall dimensions, 7¾ by 12 by 7 in. *Brennen Manufacturing Co., Brooklyn, N. Y.*

PRECISION GRINDER: Internal grinding attachment for lathes and other machine tools. Powered by standard type constant-speed, continuous-duty 1/6-hp 3450-rpm a-c motor. Motor belted through intermediate shaft to obtain quill spindle speed of 30,000 rpm. Drop in spindle speed when taking 0.003-in. cut in hardened steel, less than 1000 rpm. Four arbors permit grinding holes to 3⅞-in. deep max when using 1-in. wheel. *South Bend Lathe Works, South Bend, Ind.*

PUNCH PRESS: Capacity, 43 tons at bottom of stroke. For die cast trimming and light sheet jobs. In flywheel or geared types, with 21-in. opening through back of press. Powered by 3-hp motor. Includes 5 to 1 gearing ratio, back shaft with 230 strokes per minute speed, ram capable of 46 strokes per minute. Standard stroke, 11½ in. *Johnson Machine & Press Corp., Elkhart, Ind.*

Materials Handling

FORK TRUCKS: Battery-powered trucks in 5000 and 6000 lb capacities. Width over drive wheels, 39¼ in.; outside turning radius, 79 in.; minimum intersecting aisles, 69 in.; right-angle turn, 98 in. plus length of load; overall height, 83 in.; telescoping lift, 126 in.; initial lift, 61 in.; wheelbase, 48 in. Lower capacity model weighs approximately 9500 lb; other model, 10,500 lb. *Baker Industrial Truck Div., The Baker-Raulang Co., Cleveland, O.*

LIFT-TRUCK: Battery-powered industrial truck with hinged platform which reduces platform length by about 50 per cent. Overall length with platform in load-carrying po-

We don't Sell Your Customers

WE CARRY TUBE TO YOU

WE CARRY TUBE TO YOU

YOU CARRY ON FROM HERE

YOU CARRY ON FROM HERE

One of our prospects (prior to becoming a customer) asked us whether we would sell tubing to him and also accept orders for tubing from *his* customers.

We shouted an emphatic "No!"

That question is often asked by those who select concerns to supply material as components of their finished products or for sale over their counters.

Over many years we have maintained a definite policy of *not* competing with our customers. We try to protect their interests for we sincerely appreciate the relationship we have with them.

As a customer, you can feel free to come to us for any help you need, knowing that your problems can be discussed with us in strict confidence.

If you're our customer, we like that. And we're not your competitor, so *you* like that.

Let us be of help to you.

WOLVERINE TUBE DIVISION

Calumet & Hecla Consolidated Copper Company
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PLANTS IN DETROIT AND DECATUR, ALA.
Sales Offices in Principal Cities

sition, 109 in.; with forward end of platform raised, 84 in. Capacity, 4000 lb; weight, 3670 lb; width, 38 in.; height of head frame, 83 in.; height of platform above floor in lowered position, 7 in.; max raised height, 59 in. *Elwell-Parker Electric Co., Cleveland, O.*

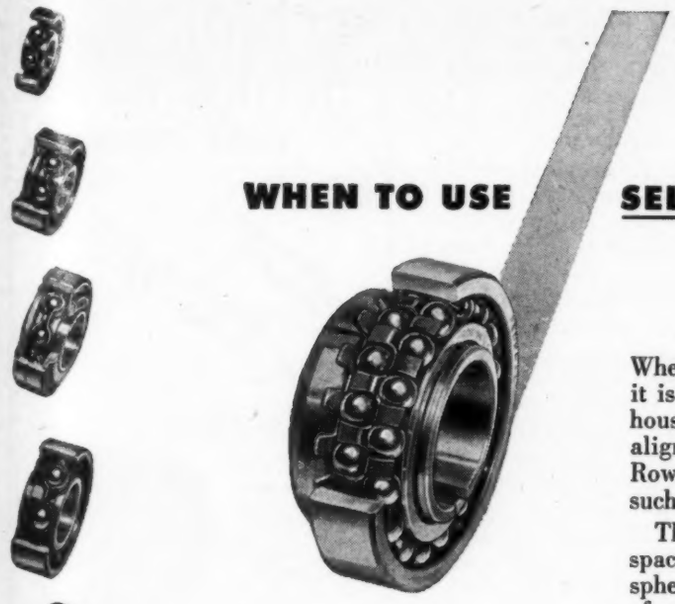
CHIP CONVEYOR: For continuous removal of chips, borings or turnings from automatic or multiple-spindle machines. Hinged steel conveyor belting will handle hot, heavy, wet or dry material. Models available to meet height and width requirements of all metal-removing machine tools. *May-Fran Engineering Inc., Cleveland, O.*

TRACTOR: For moving and spotting trailers around terminals and warehouses. Transmission, steering, fifth wheel elevator and winch all hydraulically operated. Has 8 speeds forward and reverse, can negotiate 8 per cent grade with 28,000-lb gvw at 6.7 mph or same grade with 160,000-lb gvw at 1.2 mph. Top speed, 10½ mph. Fifth wheel mechanism moves 18 in., can lift 40 tons. Winch powered directly from 100-hp tractor engine, has 16,000-lb capacity. Turning radius, 11½ ft. *Columbia Truck & Equipment Sales Inc., New York, N. Y.*

TRAMMER: Battery-powered, 1½-ton trammer for haulage work in metal mines having restricted clearances. In any gage track between 18 and 24 in. Length overall, 71½ in.; width, 35$\frac{9}{16}$ in.; weight with battery, 3000 lb; height with standard battery, 38⅛ in.; height with high type battery, 44⅛ in. Rated drawbar pull, 400 lb; max pull, 750 lb. Speed at rated pull, 2 mph; speed of locomotive alone, 7 mph. *General Electric Co., Schenectady, N. Y.*

POWER HAND TRUCKS: Two models with 6000 lb capacity. Battery-powered model has 1¼-hp electric motor mounted inside 14-in. drive wheel. Includes automatic acceleration, dynamic braking for smooth starting and stopping. Other model powered by gas engine driving hydraulic pump and motor. Hydraulic motor mounted inside drive wheel with output shaft driving through reduction to internal gear in wheel. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

ADJUSTABLE CONVEYOR: Combines standard length unit with extreme length unit, with 10 positions or adjustments available. In all standard belt widths, equipped with side rails if desired. Slide type Adjust-oveyors carry total distributed loads of 850 lb or net unit loads of 150 lb. Roller type units carry



WHEN TO USE SELF-ALIGNING DOUBLE ROW RADIAL BALL BEARINGS

Wherever shafts bend or deflect beyond the norm—where it is impossible to machine the housings in line, or when housings are mounted on separate structures and perfect alignment is impossible—Federal Self-Aligning Double Row Radial Ball Bearings meet the need for correcting such misalignment.

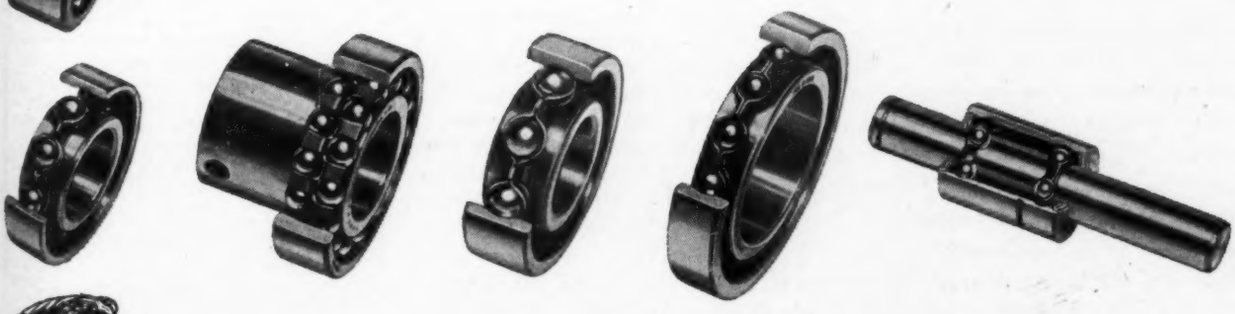
These versatile bearings are engineered so that the balls, spacer and inner ring always rotate *freely* within the spherical outer race at a considerable angle on either side of normal without binding or additional strain on the bearing parts. As a result, they are *quiet-running*, smooth-aligning and durable—solve problems which cannot be handled by ordinary radial bearings.

Federal Self-Aligning Double Row Radial Ball Bearings are made in light, extra-light, medium and heavy series; in regular and wide types for any load requirement; and in adapter and wide inner ring types for securing at any point along a plain or shoulderless shaft.

They're all described in our catalog "K," which covers the complete Federal line . . . every type and size, shielded and sealed . . . for every anti-friction need. (A few of the many types are shown here.) You'll also find ball bearing selection charts to help you compute bearing loads, determine capacities at every speed, and select the type and size ball bearing best suited to your application. Write today for your copy of this 260-page catalog. Also write for a copy of our latest Ball Bearing Conversion Tables which contain complete up-to-date interchange information.

THE FEDERAL BEARINGS CO., INC. · POUGHKEEPSIE, N. Y.

Makers of Fine Ball Bearings



FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Quality since 1908

heavier loads. Standard lengths vary from 8 ft closed/14½ ft open to 32 closed/55½ ft open. *Stewart-Glapat Corp., Zanesville, O.*

Service Equipment

LUBRICANT PUMPS: Three models of air-operated, high-pressure pumps for delivering lubricant from 25, 35 or 50-lb original containers. New sealed-in air motor has air valve and related parts located between air cylinder and pump tube. Model 711 mounted on 20½-in. square base with casters, stands 31¾ in. high, 17½ in. in diameter. Model 711-A mounted on pivot-swing dolly with semipneumatic tires and pulling handle. Model 711-B stationary without dolly or base. Pumps deliver 14½ oz of chassis lubricant per minute at 70 F with 150 psi air pressure. *Alemite Div., Stewart-Warner Corp., Chicago, Ill.*

Testing and Inspection

BINOCULAR MISCROSCOPE: Wide-field miscroscope with attachment for counting threads in fabrics. Model A low-power furnished with two pairs of eyepieces giving total magnifications of 4¼X and 6½X with fields of 1.7 and 1.3 in. Model B high-power instrument has three eyepieces giving 10X, 20X and 30X magnifications with fields of 0.63, 0.43 and 0.32-in. Focal distances for low and high power models, 8⅜ and 3⅛ in., respectively. *George Scherr Co. Inc., New York, N. Y.*

GEAR TESTER: For testing automatic transmission low planet pinions for nicks. Power spindle carries master gear, drives work pinion slipped onto second spindle. Workhead locks to engage two gears. Returning rocking handle cuts off power, brakes both spindles. *National Broach & Machine Co., Detroit, Mich.*

Woodworking Equipment

PORTABLE SAW: New lightweight 6-in. saw with universal, 60-cycle or less, 5600-rpm motor. Bevels at any angle to 45 degrees to 1½-in. depth. Cuts to two in. at 90 degrees. Housing of diecast aluminum with steel base, helical gears. Net weight, 10 lb. *Stanley Electric Tools, Div. of The Stanley Works, New Britain, Conn.*

RADIAL ARM SAW: Model GR power saw features low-dead rise, direct-drive, totally-enclosed motor. Reduced distance from bottom of motor casing to saw arbor permits feeding of thicker stock. Saw cuts to 4½ in. deep with 14-in. blade. Available with motors from 2-hp ac-dc to 3-hp single phase and from 3 to 5-hp polyphase. *DeWalt Inc., Lancaster, Pa.*

CALROD* HEATERS

"Simplest, easiest, and most reliable way to build heat into your product," says Morrison Machine Co.

This Morrison machine, built with G-E Calrod cartridge heaters, accurately shrinks the fabric in warp and weft. Temperatures, controlled by thermostats, are varied according to the fabric being shrunk.

Heat where you want it!

Only a few minutes are required to insert the cartridge heaters into the heating shoes, connect the leads, and fit the shoes over the blanketed cylinders of the shrinking machine.

LIKE THE MORRISON MACHINE CO., designers and builders of textile machinery, you may find that the simplest, easiest, and most reliable way to build heat into your product is with G-E Calrod heaters—tubular, cartridge, strip or fin.

The Morrison Co., faced with the problem of building intense, controllable heat into machines for shrinking textiles as they roll at high speed off the looms, picked G-E Calrod heaters. Here's why—

1. Use of G-E Calrod heaters cut machine manufacturing costs—workmen need only insert the heaters in the heating shoes and connect the leads.

2. Use of G-E Calrod heaters increases customer acceptance and satisfaction because the heaters are reliable and easy to operate.

The trademark, "Calrod," famous for 24 years, is a guarantee to customers that these heaters are designed to stand up under 'round-the-clock schedules. Customers can get maximum use of machinery and maximum output.

The heaters are easily controlled by thermostats, which can be set for the desired temperature up to 750 F.

*Registered Trademark of General Electric Co.

Before You Design your equipment for repetitive manufacture, get together with the G-E heating specialist in your nearest G-E office. He'll be glad to help solve your heating problems by selecting from our stock of heaters available in a wide range of standard sizes, ratings, and sheath materials.

NEW, FREE CATALOG

Write us on your letterhead for Bulletin GEC-1005A. And, if you'll also tell us about your heating problems, we'll send you application bulletins to help you select and correctly apply the right heaters to give you heat *where* you want it . . . *when* you want it . . . and in the *amount* you want it. Section 720-29, Apparatus Dept., General Electric Co., Schenectady 5, N. Y.

NEW SELLING AID

These labels, with a gummed back to enable you to place them on your machinery, are now available.

GENERAL ELECTRIC

720-29

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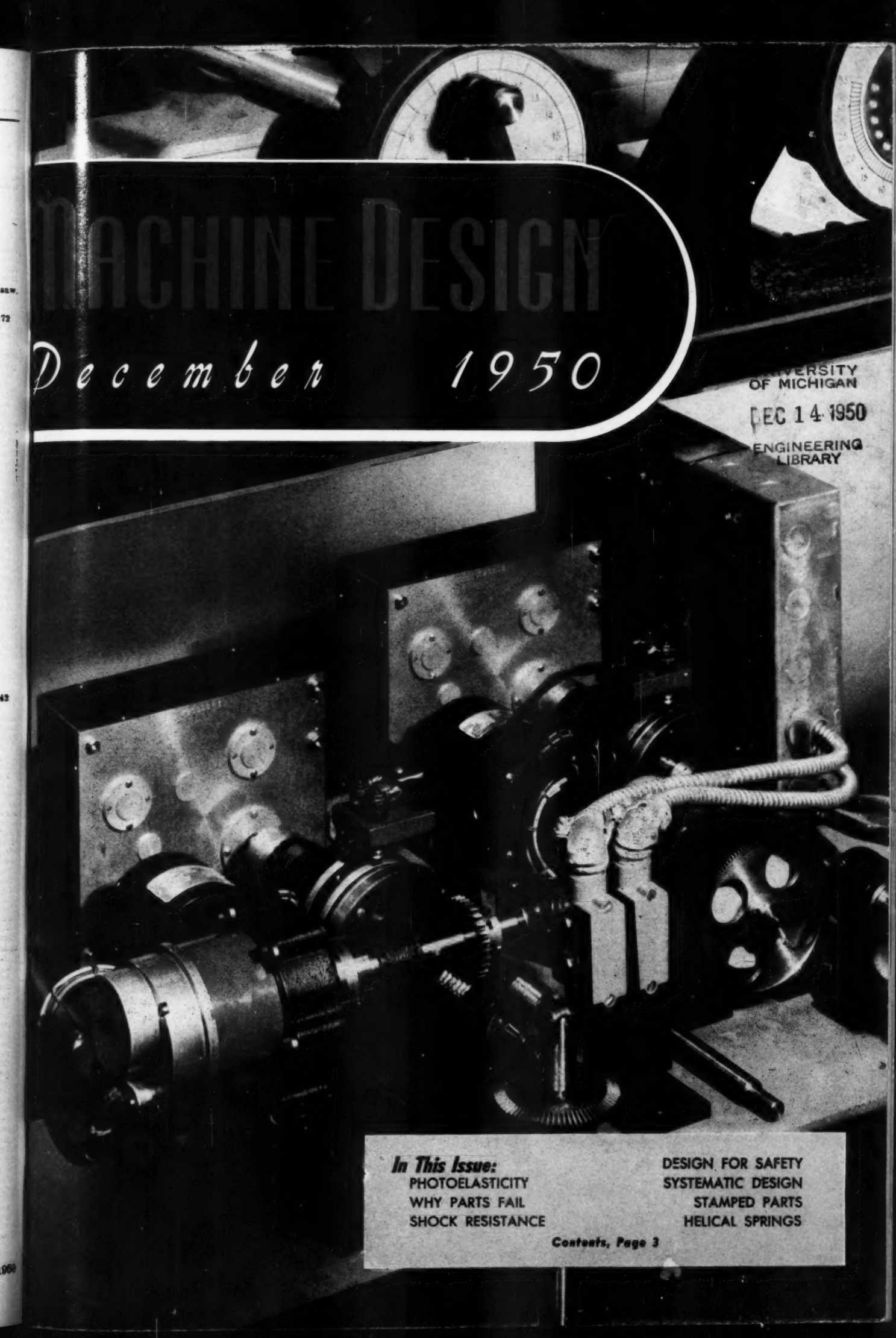

MACHINE DESIGN

December 1950

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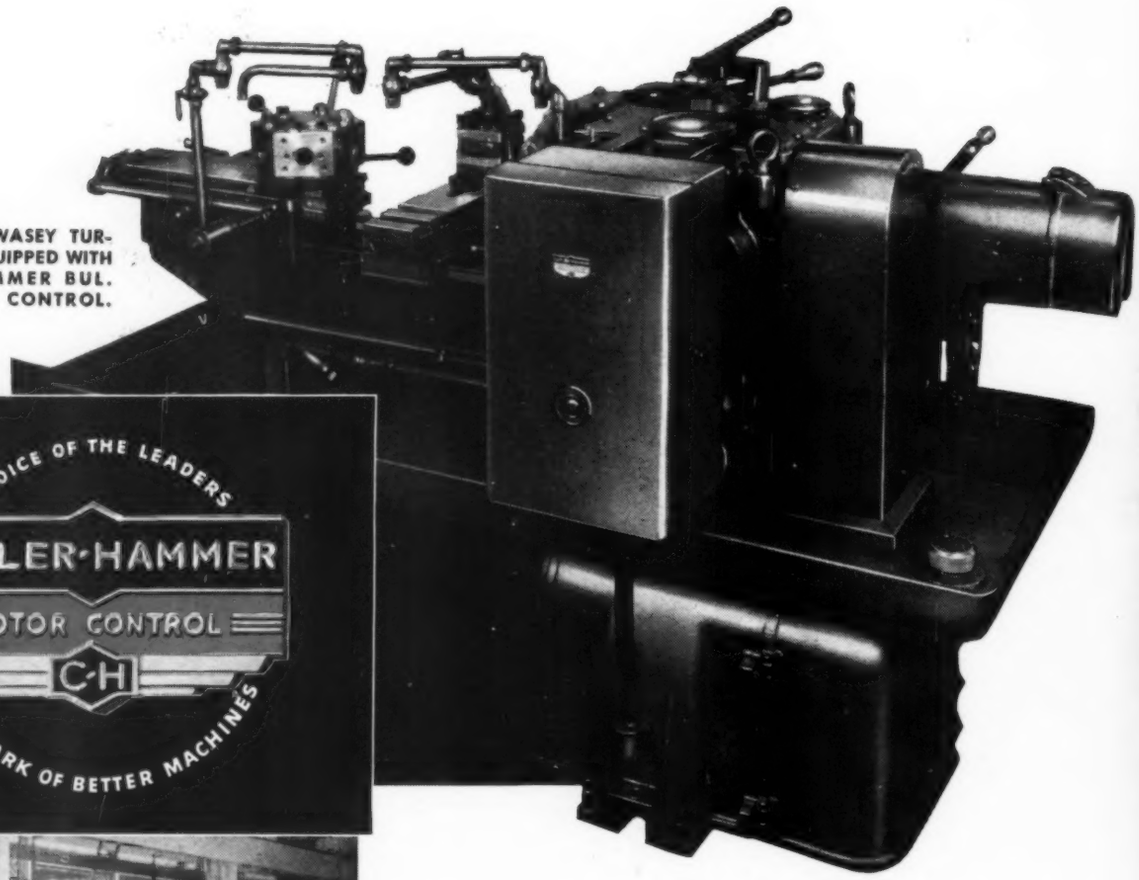

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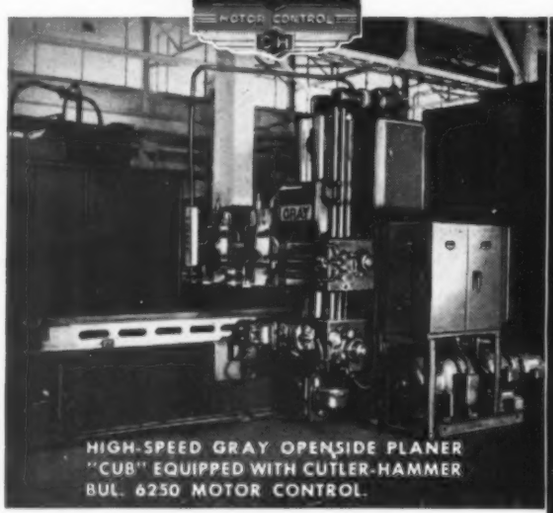

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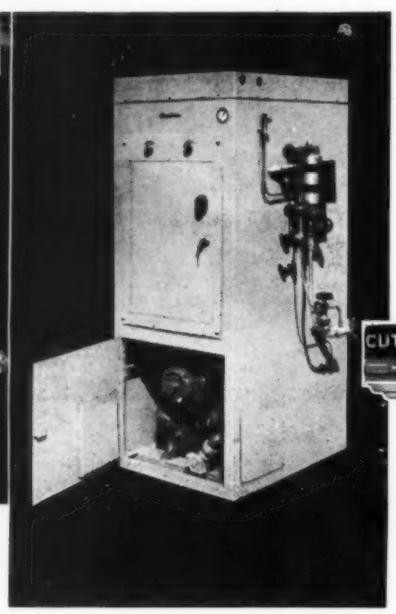

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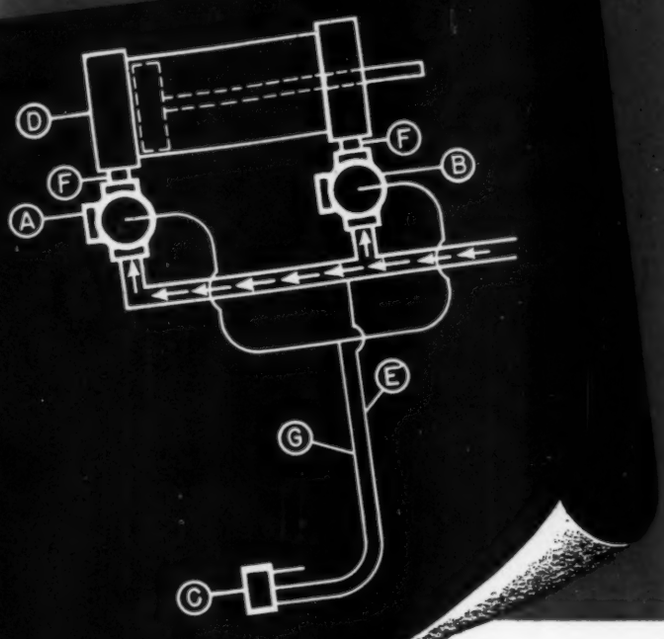

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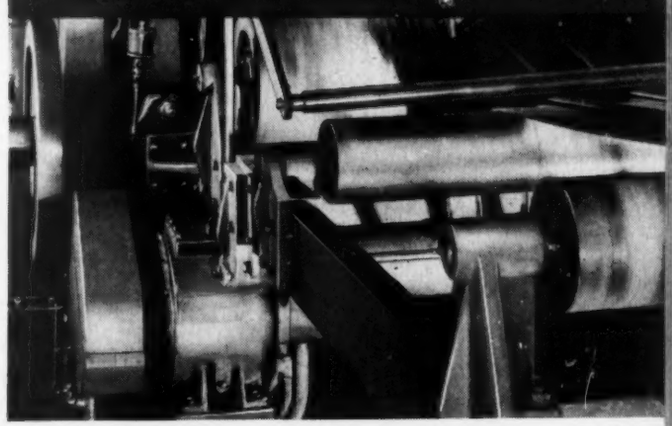
Saves Time, Money, Material

ON CHICAGO CARTON COMPANY
LAMINATING MACHINE

AND CUT-OFF



Oilgear drive installed in 1934 operates 16 hours daily at low cost. Gives maximum production on all stocks with little spoilage or non-productive time

A laminating machine and a cut-off in the plant of the Chicago Carton Company are driven in synchronism by Oilgear Fluid Power Equipment installed in 1934. A trip to the plant reveals today the compact, sturdy Oilgear equipment on the lower floor performing quietly, efficiently and continuously 16 hours a day in the necessarily humid atmosphere. Maintenance records indicate a total expenditure of $93.21 during the 16 years for service and parts, less than $6.00 a year. Because of the full flexible speed range and easy controllability of the Oilgear drives, the laminating machine is operated at speeds that best fit the type of board being processed and the cut-off drive follows in synchronism to cut stock into uniform lengths.

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LOWER—Oilgear 7½ hp Variable Speed Drive with automatic control to synchronize cutter speed with speed of laminating machine drive.

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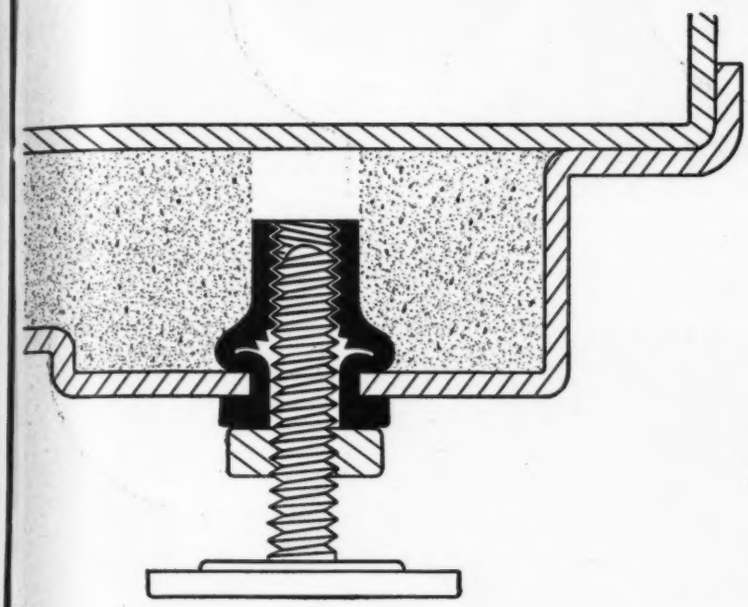

REFRIGERATOR designers had a puzzler on their hands in finding a way to fasten leveling feet to the cabinet. The metal was too thin to tap, and welding would warp it. Besides, the threads would be ruined in the enameling process.

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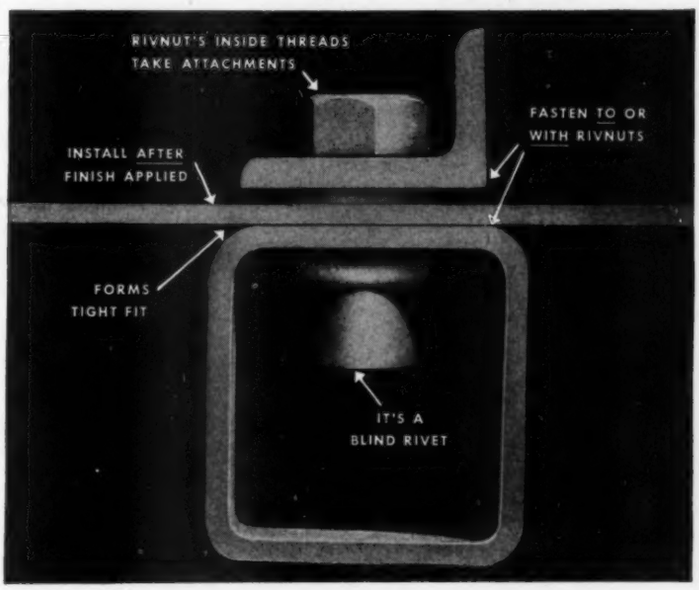

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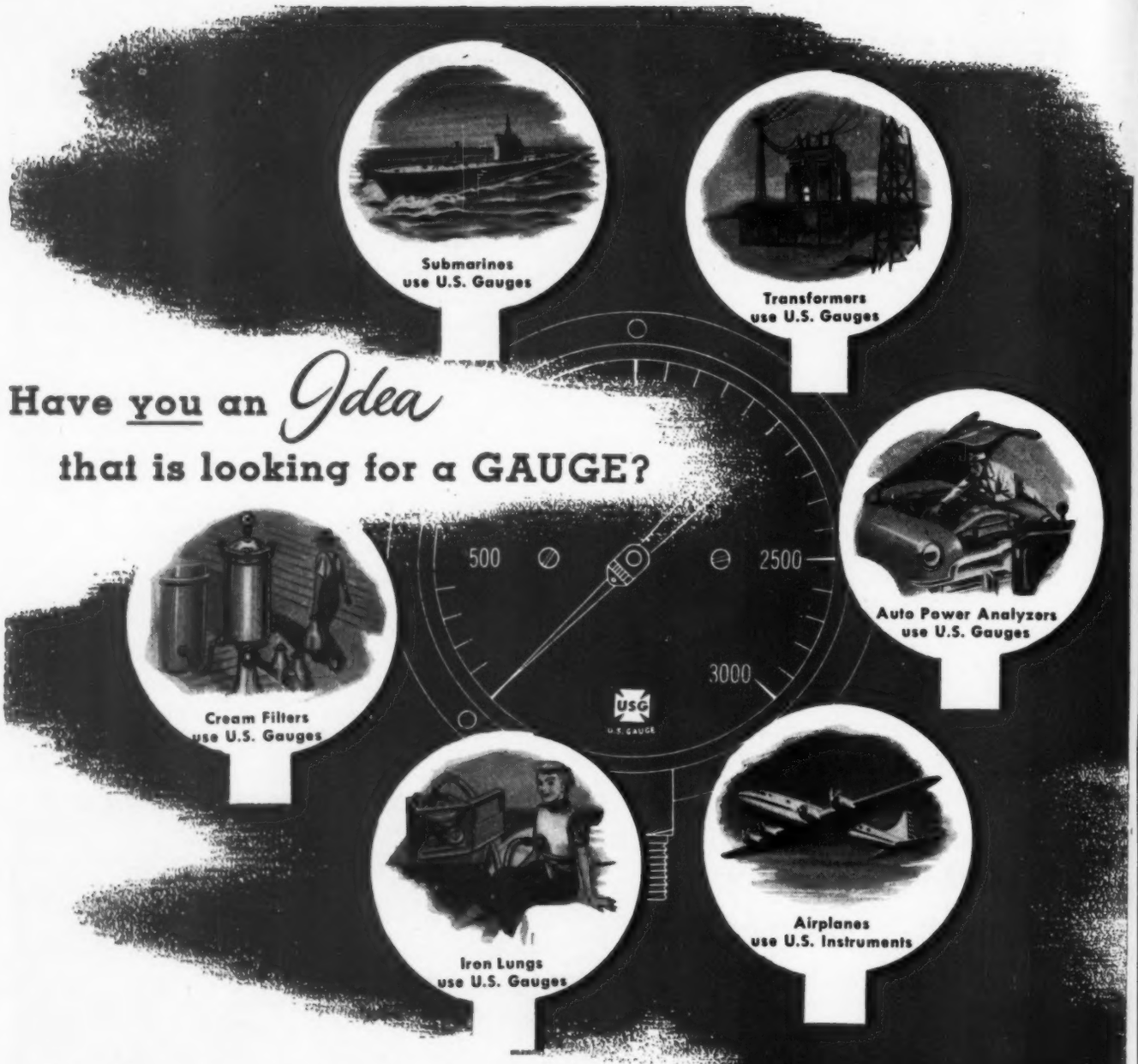

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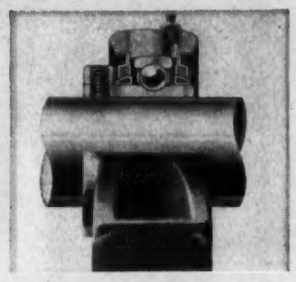

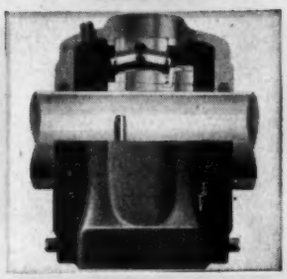

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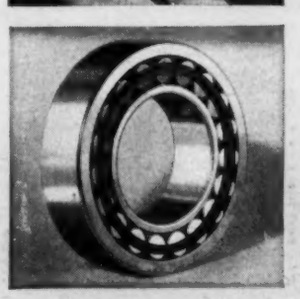

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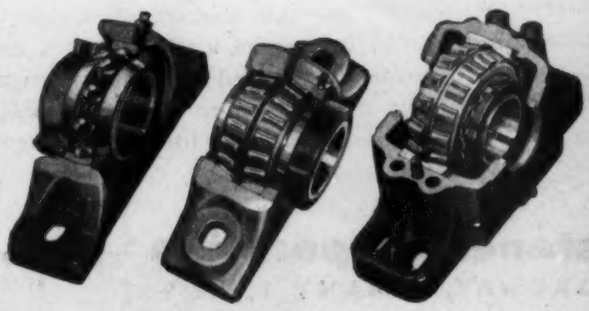

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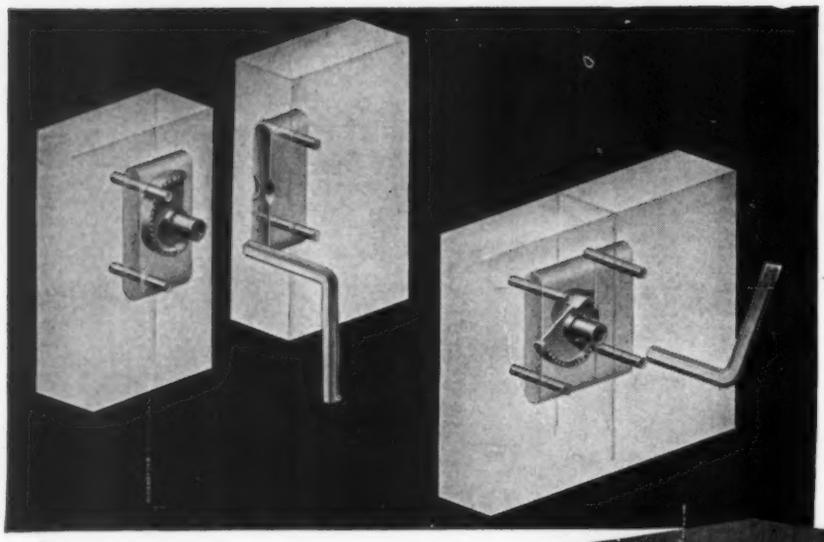
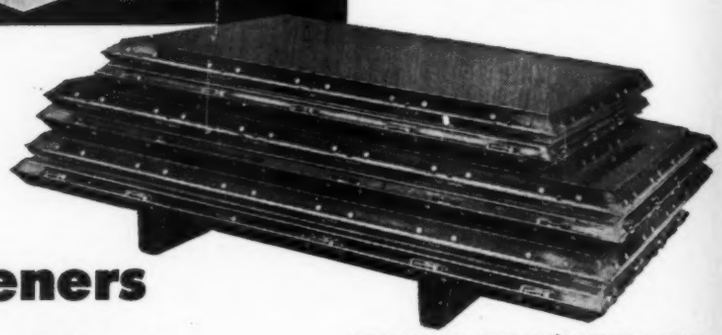


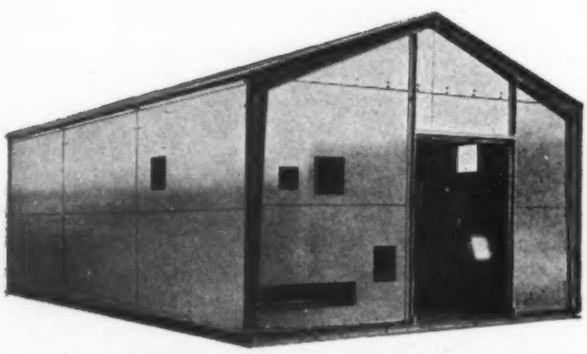
Serrated, tapered cam in male component engages lip of female. Panels are drawn tightly together when cam is turned by hex wrench, screwdriver, or any hand tool.

Lightweight air transport shipping containers, with Roto-Lock Fasteners, knock down quickly for easy return shipment.



PHOTO, COURTESY UNITED STATES PLYWOOD CORPORATION

New Roto-Lock Fasteners Solve Demountable Panel Problems



This portable shelter is made of honeycomb panels developed by the U. S. Plywood Corporation. All panels are attached with Simmons Roto-Lock Fasteners. Portable buildings are also being planned for alert hangars and maintenance hangars for fighter aircraft.

Panels of any material—equipped with the new Simmons Roto-Lock—can be fastened quickly and securely either at right angles or butt joint. No skill is required—just turn the tapered cam to lock, then turn again to unlock. Check these features of Roto-Lock...

1. Roto-Lock exerts sufficient pressure to form airtight and watertight seal when gaskets are used between panels. Carries high-tension loads as well as heavy shear loads—providing a completely structural, insulated connection.
2. Recesses completely into panels—no protruding parts.
3. Will fasten in seriously misaligned conditions—locks in any semi-open position.
4. No springs or delicate mechanical parts which may be affected by severe temperature conditions or field service.

Portable shelters, air freight and cold-storage shipping containers, walk-in coolers, demountable furniture, scaffolding, and many other designs where demountability is desirable, are using this versatile fastener. All are illustrated in our literature. Write for your copy today.

Simmons Fastener Corporation
1756 NORTH BROADWAY, ALBANY 1, N. Y.

QUICK-LOCK...
SPRING-LOCK...
ROTO-LOCK...

ANCHOR

Assembled Hydraulic Hose Units

Tailor-made to Keep Your Costs Down–Performance Up

Factory-assembled to your specifications—save you time and money, give you a better job

For extra protection against leaks and blow-offs at high pressures use factory-applied Anchor Ductile Sleeve Hose Couplings with their exclusive patented grip.

Anchor adapter unions save assembly time and piping expense. Use them and other styles of related Anchor fittings to simplify your piping problems.

FOR longer service life — you design your machines with great care and manufacture them to rigid tolerances.

But the job is not done until you invest the same care in selecting and specifying hose units. After all, the performance of your machines is dependent upon them.

That's why Anchor offers factory-assembled hose units. They are made to exact lengths in accordance with your drawings. And the couplings are factory-applied by experts with specially designed machines to give you leakproof dependability and extra safety. They cost less in the long run — because they give better service, keep your customers satisfied.

Shown here is a rayon two-braid hose-assembly designed for medium and low pressures. Made from specially selected synthetic rubber, it has excellent flexibility. This same unit is also available in a single-wire braid hose.

For high pressures Anchor Ductile-sleeve hose-couplings are your best choice.

Take out performance insurance. Reduce assembly time and costs in your plant and in the field. Equip your machines with Anchor factory-assembled hose units.

Send for complete information on Anchor assembled hose units.

Tear out this coupon and mail TODAY!

ANCHOR COUPLING CO. INC.
Libertyville, Illinois

I like the dependability, the safety, and the time-and-money-saving features of Anchor Assembled Hose Units. Please send me Bulletin No. 495.

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Company.....

Company Address.....

City..... ( ) State.....

D-2

ANCHOR COUPLING CO. INC.
Factory Libertyville, Illinois • Branch Detroit, Michigan

MICRO SWITCH *Engineering Service* — is geared to

FIELD SERVICE

How MICRO SWITCH Engineers helped meet stringent switch requirements for jet-propelled Banshee fighter

DEVELOPMENT of jet-propelled aircraft has created new problems and placed new demands on materials and component parts.

Engineers of McDonnell Aircraft, St. Louis, called on MICRO SWITCH ENGINEERING SERVICE, long experienced in solving aircraft switch problems, to help them meet the stringent switch requirements for the Banshee jet-propelled Navy fighter.

MICRO SWITCH designed new dependable precision switches for control of the wing-lock mechanism as well as switches to meet other exacting requirements. The long-continued efficient operation of these MICRO products is a matter of record.

You probably don't build jet planes, but if the product you do make requires precision snap-action switches for a tough application, call on MICRO SWITCH ENGINEERING SERVICE—the service responsible for creating more than 4600 different switches for specific industrial requirements. Call or write MICRO SWITCH, Freeport, Illinois, or any of our branch offices.

o tough application problems!

PRODUCT DEVELOPMENT

ADAPTABILITY STANDARDS

An ideal high-capacity MICRO precision switch to handle high inrush current!

(insert)
MICRO
BAFI-2RN2

These high-capacity switches (with either plunger or roller arm actuators) are designed to handle the high inrush current required in operation of solenoids, motors and tungsten lamps.

They are ruggedly housed and sealed to resist entrance of dirt, dust, oil and moisture.

They are Underwriters' Laboratories listed for 1½ HP motor, 230 volts a-c; ¾ HP motor, 115 volts a-c; 20 amperes, 125, 250 or 460 volts a-c; tungsten lamps, 10 amperes, 125 volts a-c. Rated for 75 amperes inrush capacity at voltages up to 460 volts a-c.

The MICRO BAFI switches are typical of MICRO SWITCH's continuing development of new precision switches to meet the ever-widening needs of design engineers.

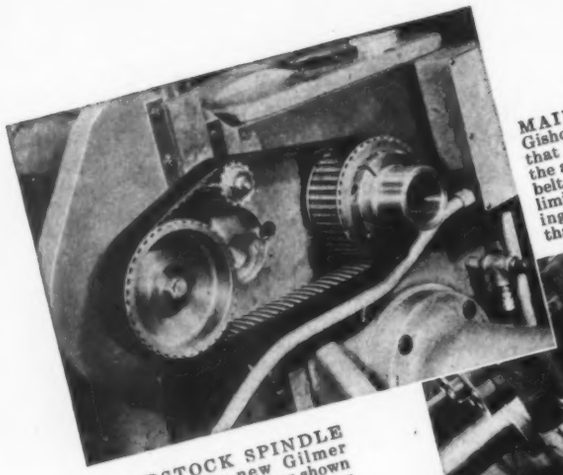
MICRO SWITCH ENGINEERING provides just the right actuator type for every design need

1. **PIN PLUNGER** where accurate repetition of operating point is a prime requisite.
2. **"S" PLUNGER** for application where travel of actuating device is less accurately controlled.
3. **"D" PLUNGER** large diameter plunger to facilitate operation by slow-moving cams.
4. **"Q" PLUNGER** for manual or mechanical push-button switches to be mounted through panel.
5. **LEAF ACTUATOR** for use by operating means which combine small force with limited overtravel.
6. **ROLLER LEAF ACTUATOR** suited for actuation by clock motors and other low-energy means.
7. **"W" LEVER** designed for operation by slow-moving cams or slides and similar actuating means.
8. **"W2" ROLLER LEVER** with roller assembly at lever tip . . . for fast-moving cam actuation.
9. **"W22" ROLLER LEVER** for actuation by fast-moving cams where compactness is an important factor.

MICRO... first name in precision switches

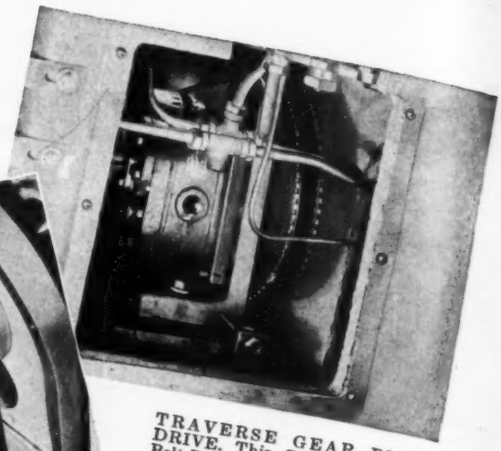
MICRO MS SWITCH
TRADE MARK
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
FREEPORT, ILLINOIS, U. S. A.

Branch offices in principal cities of the United States and Canada



HEADSTOCK SPINDLE DRIVE. The new Gilmer "Timing" Belt Drive as shown above enables Gisholt to cover a considerable range by simply varying the number of teeth on driving or driven pulley and compensating with idler.

MAIN SPINDLE DRIVE. Gisholt design engineers found that an electric brake decreased the available room for a standard belt drive, but despite these space limitations the new Gilmer "Timing" Belt Drive proved more than adequate.



TRAVERSE GEAR PUMP DRIVE. This Gilmer "Timing" Belt Drive operates the gear pump, which maintains pressure in the hydraulic cylinders actuating the traverse mechanisms. Because the Gilmer "Timing" Belt makes positive contact with the pulleys, all slippage due to the presence of oil is eliminated.

GISHOLT solves design problems with the revolutionary, tooth-grip GILMER "TIMING" BELT* DRIVE

Here's the most revolutionary idea to hit belt drives in years! It's the tooth-grip Gilmer "Timing" Belt Drive—running in axial grooved pulleys—the only belt that makes positive engagement with the pulleys. No slip . . . no creep . . . no stretch! This tooth-grip belt has steel cables imbedded in Neoprene for greater pulling power. Provides the answer to many tough design problems.

For instance, in the production of the No. 12 Hydraulic Automatic Lathe, the design engineers of the Gisholt Machine Company in Madison, Wisconsin, were confronted with the following problems:

1. A single drive to operate the spindle from 400 to 1600 r.p.m., which previously had only been accomplished by a combination of gears or belts.

2. Space limitations.

3. Belt slippage caused by oil.

The Gilmer "Timing" Belt Drive accomplished all this, plus the elimination of an auxiliary electric motor (for the Multiple V-belt Drive) when the higher spindle speeds were required.

This was not surprising, in view of the unique features of the Gilmer "Timing" Belt Drive. It is efficient up to speeds of 15,000 f.p.m. What's more, extreme ratios are practical, so that the Gilmer "Timing" Belt Drive takes advantage of space limitations. And belt slippage is eliminated altogether, because of the "Timing" Belt's tooth-grip construction.

Many other engineers have discovered the same thing as those at Gisholt: Gilmer's "Timing" Belt Drive helps to streamline their designs. It can improve yours, too. Check this belt's many advantages listed at the right for the solution to YOUR design problem.

*Patented

Gilmer also manufactures: V-belts, flat belts, round belts, fan belts — and many others, both endless and connector types.

Only the tooth-grip Gilmer "Timing" Belt can offer all these amazing features

1. COMPLETELY POSITIVE DRIVE. The only belt that makes positive engagement with the pulleys. Teeth and groove engagement of belt with pulleys eliminates slip, creep, speed variation.

2. PRECISION TIMING. Speeds of driver and driven pulleys synchronize perfectly, guaranteeing uniform r.p.m. every moment of operation.

3. NO STRETCH. Steel cable pulling element eliminates elongation.

4. LOW OR HIGH SPEEDS. Efficient for low speeds at inches per minute, or high speeds up to 15,000 f.p.m.

5. FIXED CENTERS—NO ADJUSTMENTS. Wire cable construction permits belts to operate on fixed centers without take-up adjustments.

6. NO INITIAL TENSION. Belt does not depend on initial tension. This results in high efficiency and extremely low bearing pressure.

7. HIGH TENSILE STRENGTH. Steel cables give belt greater pulling power. Size of belt can be varied to provide for any horsepower requirements.

8. LOW OPERATING NOISE LEVEL. Tests prove the "Timing" Belt Drive quieter than precision gears running in an oil bath.

9. NO LUBRICATION. Belt requires no lubrication or dressing. Oil, however, does not harm the belt.

10. COMPACTNESS. Substantial space saving is general on Gilmer "Timing" Belt Drive applications. Extreme ratios are practical.

11. SMALL PULLEY DIAMETERS. Belt's extreme flexibility permits pulley diameters as small as ½" at 10,000 r.p.m.—even with a comparatively heavy load.

12. ECONOMICAL. Maintenance cost is low because of absence of take-up from stretch, elimination of lubrication, infrequent replacements and elimination of power waste. Moreover, initial cost may be lower than for other types of drives because of smaller drive dimensions.

13. VERSATILE. Belt can be used as a power transmission belt, timing part, or other functional part.

Gilmer BELTS

Gilmer has the PULL!

L. H. GILMER COMPANY, 1203 Tacony, Philadelphia 35, Pa. Division of United States Rubber Company

Let us help you solve your SPEED REDUCER PROBLEMS

Farrel speed reducers have incorporated in them the experience gained in the solving of innumerable problems requiring considerable pioneering in gear engineering. The result is a wide range of types (a few of which are illustrated here), that are standard in principal features, but adaptable in critical detail.

All units are supplied with precision gears, generated by the famous Farrel-Sykes process for smooth, quiet, efficient power transmission; shafts and bearings factored to safeguard against interruption of vital processes; gear cases proportioned to withstand repeated heavy peak loads; joints sealed to prevent entrance of dust and dirt.

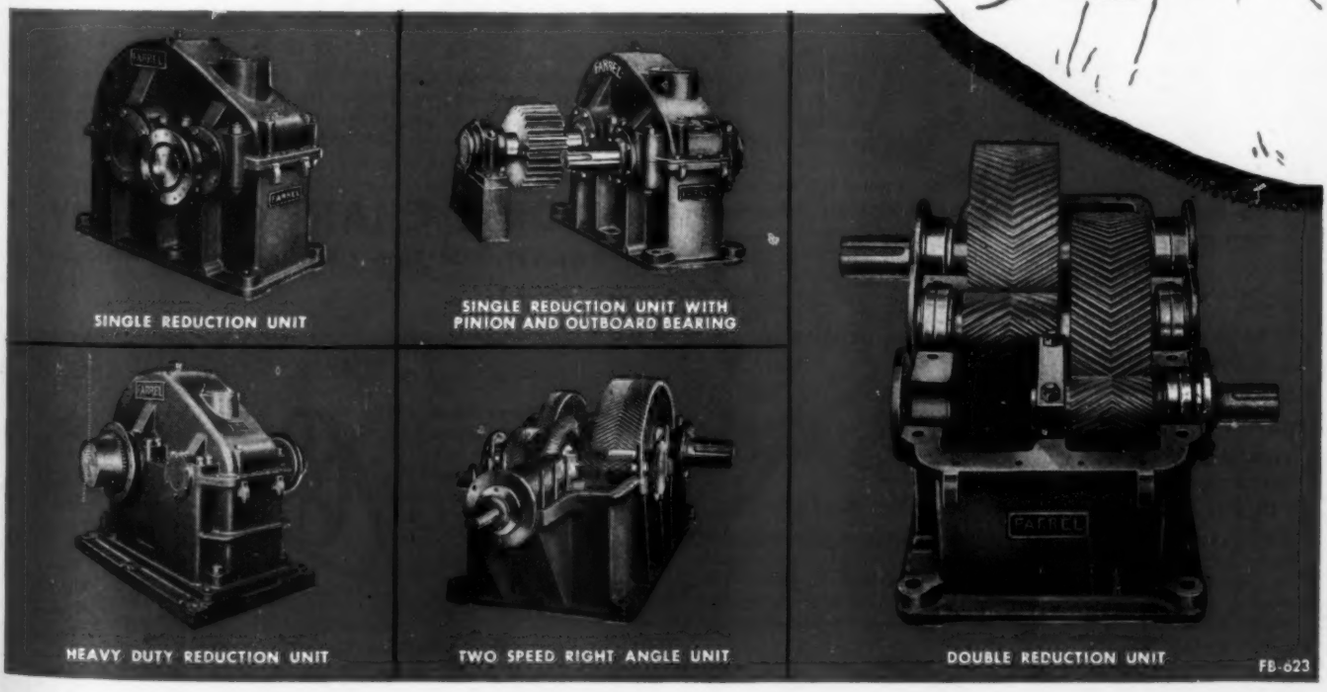
But, that is not all. Without sacrificing the advantages of general standards, the design of these units permits an engineering freedom in proportioning gears, shafts, bearings and even some housing dimensions to meet specific load, speed and service requirements. This flexibility has resulted in the solution of innumerable application problems.

Write for further details. Ask for a copy of Bulletin 449 —no cost or obligation.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y., *Sales Offices:* Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Cincinnati, Detroit, Chicago, Los Angeles, Tulsa, Houston, New Orleans

Farrel-Birmingham®

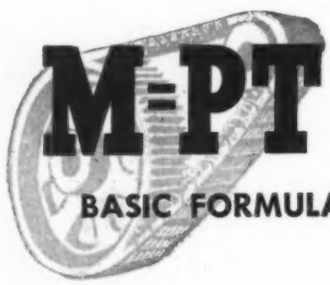


for hauling CEMENT or designers rely on MORSE

Furnishing candy for the nation's sweet tooth and handling heavy materials like cement are activities that call for machines that are entirely different. But designers of equipment for both types of jobs have chosen Morse Power Transmission Products for performance and dependability. In its Moto-Bug power wheelbarrow, the Kwik-Mix Company uses a Morse-Rockford Double Pullmore Clutch and a Morse Roller Chain Drive to the front wheels. The Currie Manufacturing Company uses three sizes and dozens of feet of Morse Roller Chain in its labor-saving, automatic starch tray stackers and feeders for candy makers.

Morse—Unlimited in Applications

Whatever your mechanical power transmission needs—for clutches, for precision-made roller or silent chain or sprockets, for couplings or drive shafts—Morse can fill them. Morse engineers' wide experience in solving power transmission problems for almost every industry, and Morse's long record of producing a great variety of the finest mechanical power transmission equipment are your assurance that M=PT, Morse *means* Power Transmission.



Morse *means* Power Transmission

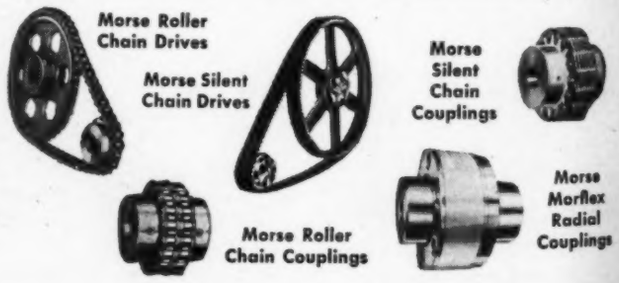
For more complete information about Morse Roller Chains and Sprockets, write today and ask for Catalog C51-50. For the full clutch story, ask for Pullmore Clutch catalog.

Ask the Morse Man for power transmission information!

MORSE CHAIN COMPANY
Dept. 581, 7601 Central Avenue, Detroit 8, Michigan

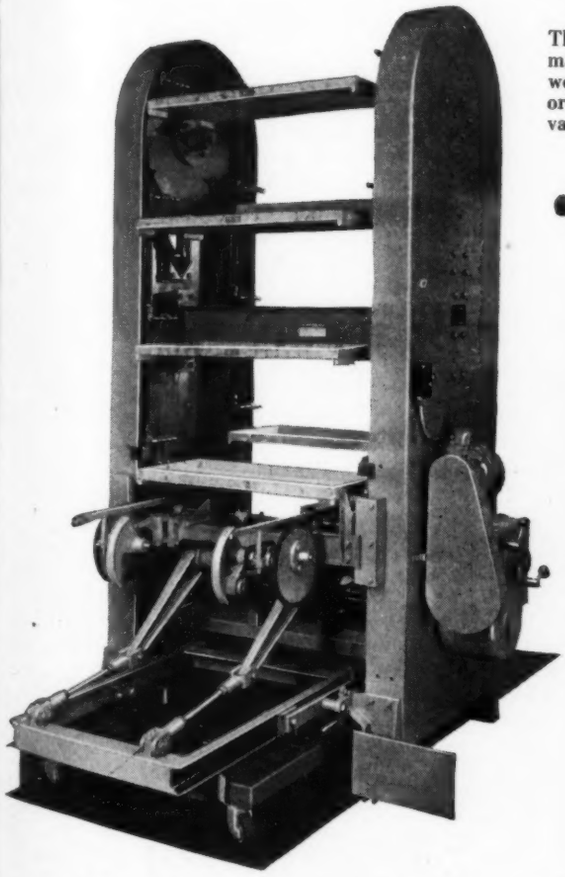
100 Morse Branch Offices and Distributors to supply your power transmission demands.

From coast to coast there are more than 100 offices, representatives and distributors of Morse Power Transmission products to give you quick information and service when you want it—where you want it. *Ask the Morse Man first in any case!* Check your classified phone directory under **"Power Transmission"** or **"Chains"** for the nearest Morse Man.



making CANDY...

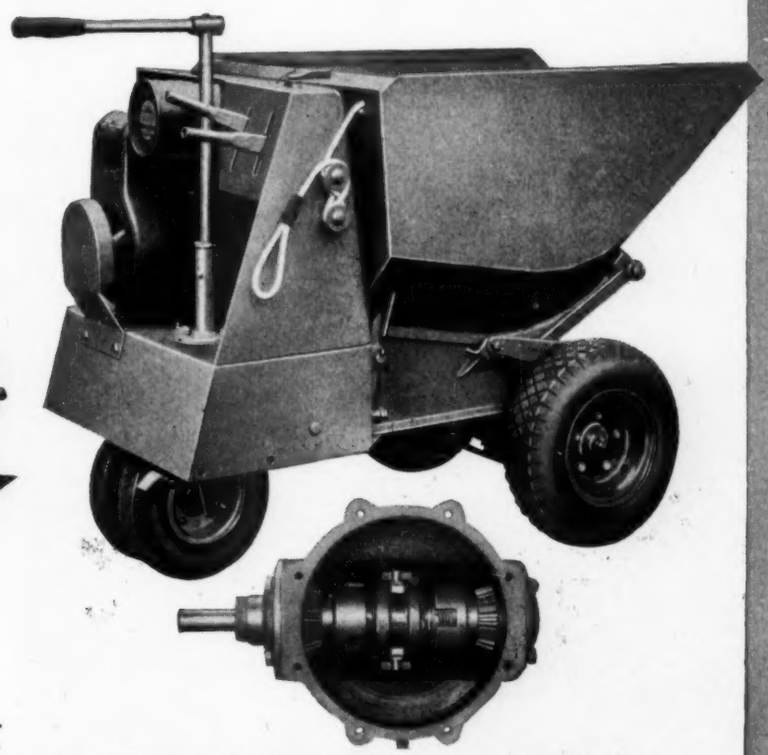
POWER TRANSMISSION PRODUCTS



Currie automatic starch tray stackers and feeders increase production, reduce tray breakage for candy manufacturers. Since their development about ten years ago, these machines have been equipped with Morse Roller Chain.

Morse Roller Chain provides positive power transmission without slippage, saves space, allows design freedom. Morse Roller Chain is precision-built for long, trouble-free service under a wide variety of working conditions. It uses teeth, not tension; gives 99% efficiency.

The Kwik-Mix Moto-Bug takes the hard work and high cost out of materials handling, the pulling and pushing out of wheelbarrow work. With a capacity of 1200 pounds or ten cubic feet in its hopper or on its interchangeable platform, the Moto-Bug handles a wide variety of materials.



Double Morse-Rockford Pullmore Clutch on versatile Moto-Bug is used on main drive. It provides forward or reverse motion at full power. Particularly compact, powerful, smooth-running, the clutch has proved its efficiency, economy, and reliability in rugged service. Morse-Rockford Pullmore Clutches are made in single and double types, for dry operation or operation in oil in many capacities ranging from one to ninety horsepower at 500 r.p.m.

Morse Morflex Couplings

Morse-Rockford Clutches

Morse Morflex Drive Shafts

Morse-Rockford Pullmore Clutches

MORSE

MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF BW BORG-WARNER

The Light

THAT MUST NOT FAIL

Automatic Airway Beacon Controlled by Telechron Timing Motor

Today's modern airfields leave nothing to chance. Airway beacons and airstrip lights flash on *automatically* at the first approach of dusk. Whether "dusk" occurs in mid-afternoon or at its duly appointed time, pilots need not fear for proper guidance while in flight. Lights respond to pre-determined light levels and function the instant they are needed.

Weston illumination controls permit this uniformly reliable regulation of lighting. Independent of human judgment or arbitrary light schedules, it is a great advance in aviation safety. These controls owe their dependability to Telechron Timing Motors — also used in aircraft instruction markers, street lighting and industrial lighting.

Instantly, constantly synchronous, Telechron Timing Motors give dependable performance every time.

Timing On Your Mind?

If you have a timing problem to contend with, a Telechron application engineer can be of great help to you. Backed by broad field experience, he can lead you to important savings in time and money. Consult him early in your planning. For immediate facts, send coupon below. TELECHRON INC. A General Electric Affiliate.

Telechron®

ALL TELECHRON TIMING MOTORS ARE INSTANTLY...CONSTANTLY SYNCHRONOUS

TELECHRON INC.
23 Union Street
Ashland, Massachusetts

Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

Instruments	☐	Communications Equipment	☐
Timers	☐	Other (please fill in)	
Electric Appliances	☐	.....	
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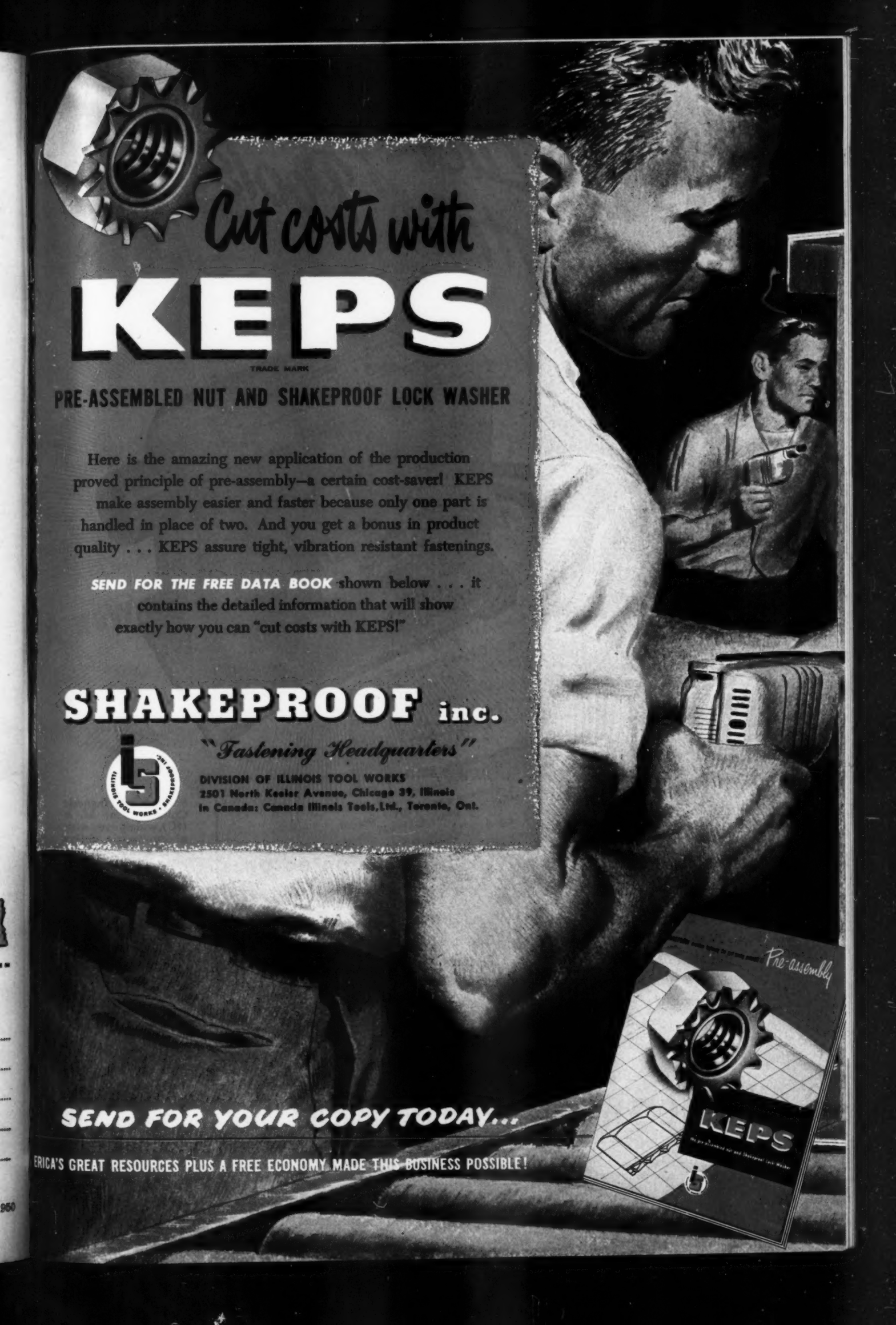
Cut costs with
KEPS
TRADE MARK
PRE-ASSEMBLED NUT AND SHAKEPROOF LOCK WASHER
Here is the amazing new application of the production proved principle of pre-assembly—a certain cost-saver! KEPS make assembly easier and faster because only one part is handled in place of two. And you get a bonus in product quality . . . KEPS assure tight, vibration resistant fastenings.
SEND FOR THE FREE DATA BOOK shown below . . . it contains the detailed information that will show exactly how you can "cut costs with KEPS!"
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Pre-assembly
KEPS
SEND FOR YOUR COPY TODAY...
ERICA'S GREAT RESOURCES PLUS A FREE ECONOMY MADE THIS BUSINESS POSSIBLE!

Try Your Luck In Untried Pools!

...You may Land a Big One that you never counted on

You may get a strike that will amaze you . . . and your customers, too. You may net a whopper that will weigh up to be *the biggest sales advantage your product ever had*... the hidden ability to count to your customers' advantage. Like the milling machine builder who found he could build-in a Veeder-Root Counter to pre-set and control depth of cut.

And on such fishing expeditions, V-R engineers are expert (and remarkably successful) guides. When do you want to try *your* luck? Just write.

Series 1200 Magnetic Counters (for AC & DC), widely used with photo-electric relays or electric-eye equipment. These and scores of other electrical and mechanical counters are shown in FREE 8-page "COUNT BOOK" below. Send for your copy, *today*.

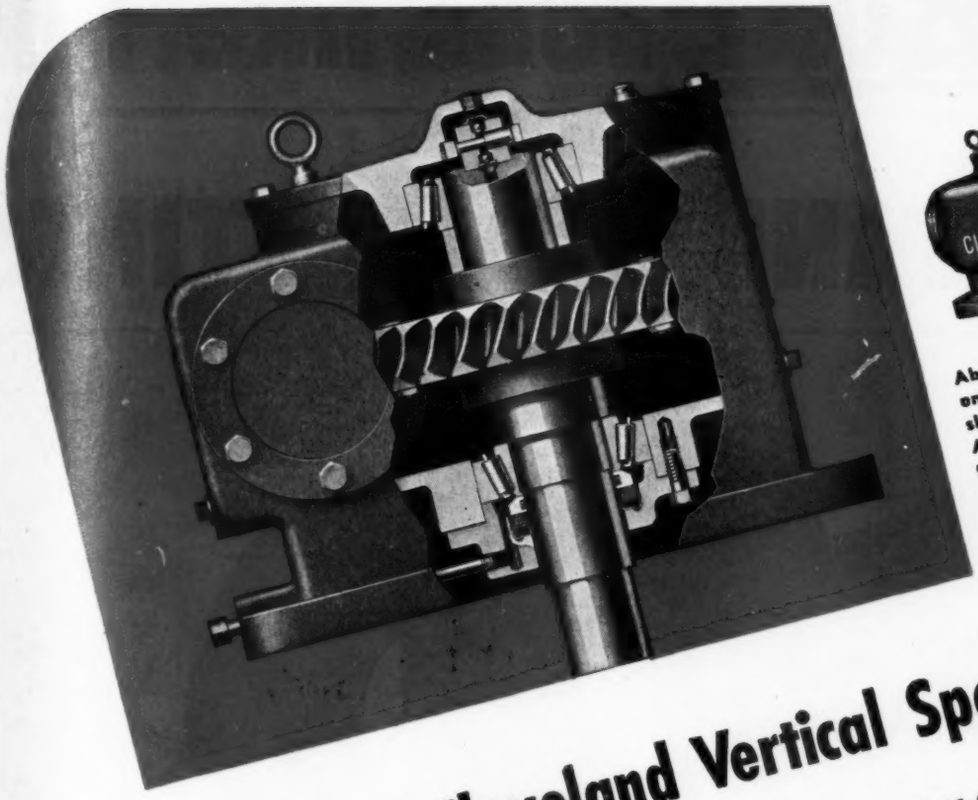
Veeder-Root COUNTERS

"Count Everything on Earth"

VEEDER-ROOT INC., HARTFORD 2, CONN.

Veeder-Root Inc., Hartford 2, Conn., (NEW Telephone Number: HArtford 7-7201)

In Canada: Veeder-Root of Canada, Ltd., 955 St. James Street, Montreal 3
In Great Britain: Veeder-Root Ltd., Kilspindie Rd., Dundee, Scotland



Above—Exterior view Type ND unit. NU unit (not shown) has slow-speed shaft extending up. At left—Cutaway section to show tapered roller bearings on gear shaft, positive face-type oil seal, unique lubricating pump and oil drain at base of housing.

A new series of Cleveland Vertical Speed Reducers

● NU and ND worm gear units—in seven sizes each (50 to 500) are ready for prompt delivery. They are particularly suited to such equipment as agitators and mixers, and to overhead chain conveyors as well.

Outstanding features which insure that these new vertical drives will deliver long and trouble-free service are:

Extra heavy tapered roller bearings on gear shaft.

Continuous lubrication of top bearing by positively driven pump mounted on upper end of gear shaft (on lower end in Type NU).

Positive face-type oil seal below lower gear shaft bearing to prevent leakage.

Heavy base flange extends around all four sides. All parts liberally sized and precision built.

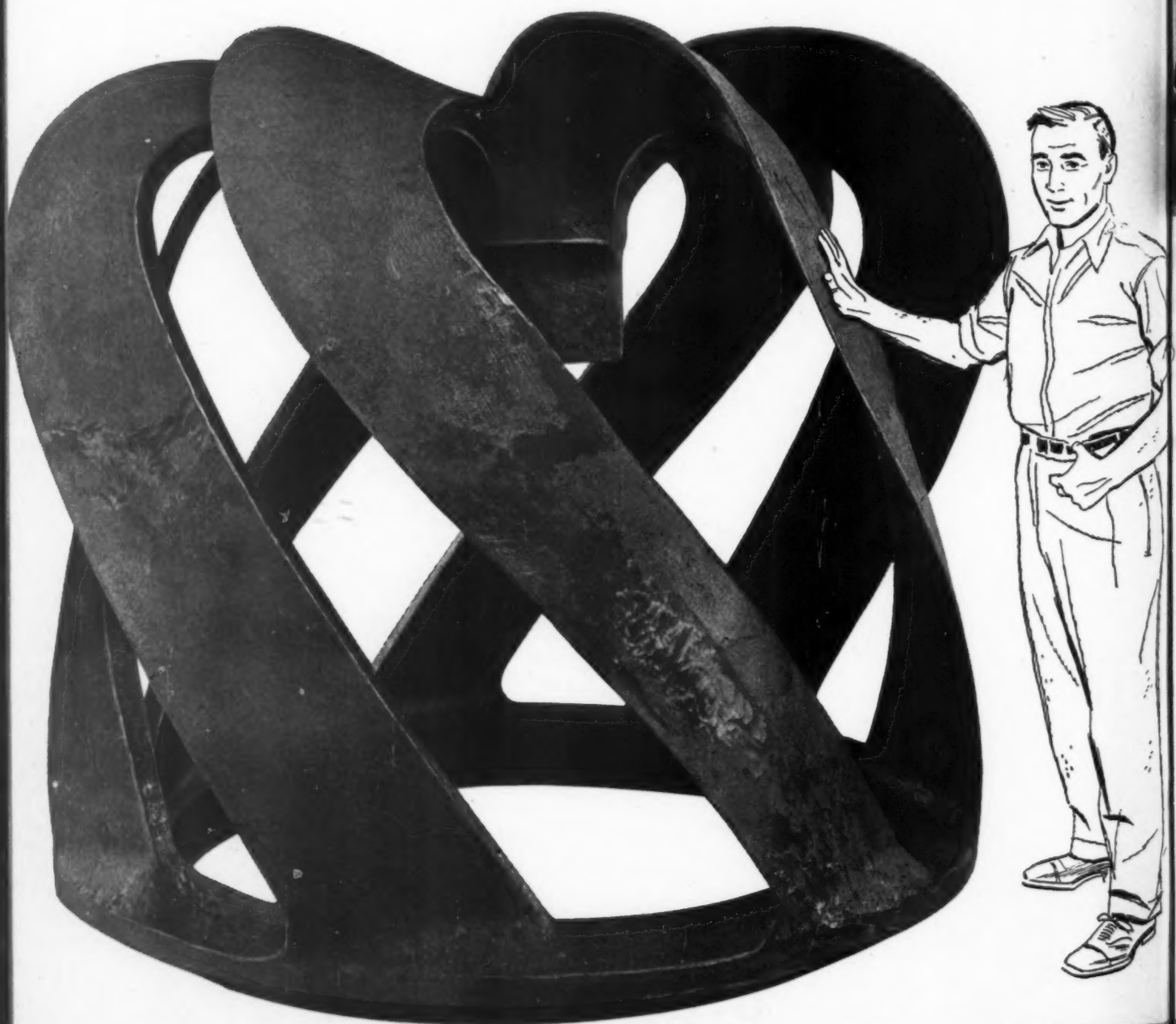
Write for Bulletin 125 for full description of Types NU and ND, including capacity charts and dimension data. The Cleveland Worm & Gear Co., 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

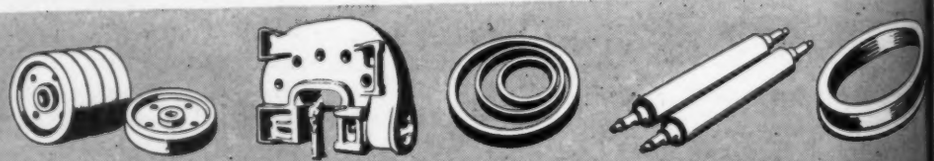
CLEVELAND
Worm Gear
Speed Reducers

UNUSUAL Jobs like this

of STANDARD CASTINGS

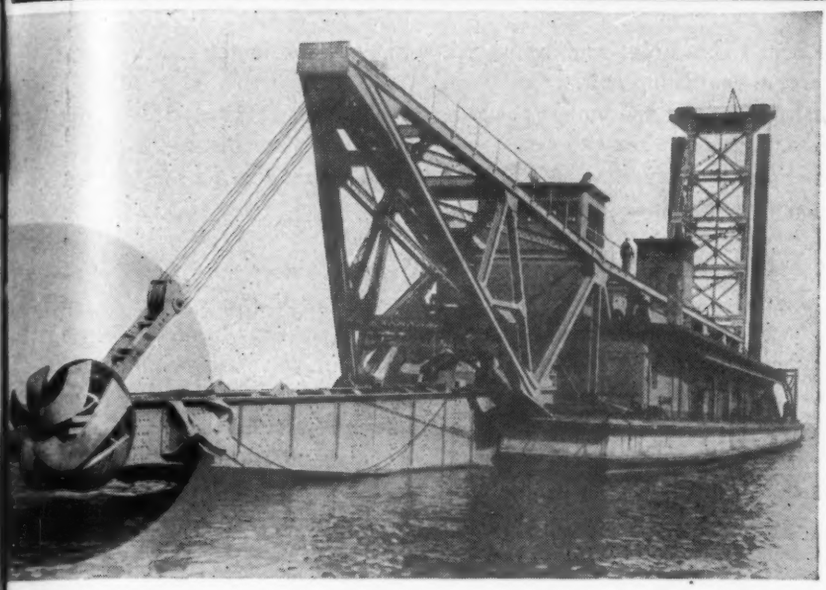


STANDARDIZE ON
STANDARD FOR—



WHEEL MILL PRODUCTS, STEEL CASTINGS, WELDLESS RINGS, FORGINGS, FLANGES

Certify the USUAL properties

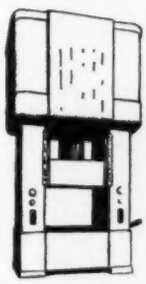


The giant cutter heads on Ellicott Hydraulic Dredges have a really tough job to do. They chew sand, silt, mud, clay, cemented gravel and disintegrated rock from the beds of rivers and lakes, loosening the material so it can be sucked up and discharged hydraulically.

Service of the heads calls for superior service qualities in the castings. Production of the heads calls for superior know-how in the pattern shop and on the casting floor. Ellicott found a single answer to these twin requirements—Standard Steel Works castings.

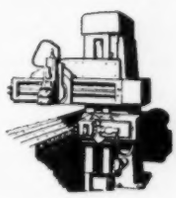
Big enough to have every needed facility—small enough to give every order careful, individual attention—Standard is a dependable source of supply for *unusual* castings which because of size, complication or special properties are beyond the abilities of the average foundry. If your casting requirements are in this category . . . just get in touch with Standard.

Standard has produced some of the largest turbine runners ever installed, for some of the nation's greatest hydro-electric developments.



Massive parts for mammoth presses, where loads run into hundreds of tons and the soundest, strongest castings are essential, are regularly produced at Standard.

Castings for bridge supports, and similar miscellaneous castings for structural or other uses, can be produced in any size and quantity in Standard's modern foundry.



Frames, bed plates and similar members for precision machine tools often demand special properties and unusual quality in the castings. Standard specializes on such production.

NOTICE

ATTENTION: DESIGN AND PURCHASING DEPARTMENTS

Standard is equipped to produce castings ranging in weight from 5 to 130,000 pounds for all classes of service. Recent developments in chemical compositions and heat treatments produce substantial improvement in physical properties. Whatever your needs —let Standard quote on your requirements.

BLW THE BALDWIN GROUP

BALDWIN

STANDARD STEEL WORKS DIVISION

THE BALDWIN LOCOMOTIVE WORKS: Standard Steel Works Division, Burnham, Pa., U. S. A.
Offices: Chicago, Cleveland, Houston, New York, Pittsburgh, San Francisco, St. Louis, Washington.

Here's the motor that "couldn't be built"!

It's the Holtzer-Cabot quiet-running capacitor motor — the motor that powers the Nesbitt schoolroom ventilating unit.

Previously, the hum of A.C. motors powering these units had proved so distracting as to be impractical. Hence, when alternating current only was available, motor-generator sets were required to convert to D.C.; but this arrangement was not too satisfactory because of the excessive additional cost.

Quite a problem!

The obvious solution was a really quiet A.C. motor — something that had never been achieved up to that time. Holtzer-Cabot engineers went to work on the problem. The result was an A.C. motor that performed perfectly . . . *and silently!*

Today, schools from coast to coast are using Nesbitt ventilator units in each room to furnish a continuing supply of fresh sweet air. These units, many of which are powered by Holtzer-Cabot motors, operate efficiently and quietly, and make possible full concentration in the classroom.

This is just another example of Holtzer-Cabot's ability to meet the most exacting specifications in small-motor applications. Holtzer-Cabot motors range from 1/2000 up through 1½ H.P., from 24,000 RPM to 1 revolution per day!

The Holtzer-Cabot RWC-6417, an improved version of the first silent A.C. motor developed to Nesbitt Co. specifications. Single phase, 1/12 H.P. single value capacitor type, with totally enclosed wool-packed sleeve bearing and a resilient base mounting. Shaft is 43" overall, ¾" in diameter, adjustable variable speed. Gives trouble-free performance.

HOLTZER-CABOT

DIVISION OF NATIONAL PNEUMATIC CO., INC.

BOSTON 19, MASSACHUSETTS

"Manufacturers of fine electrical apparatus since 1875"

INVESTIGATE NOW... Holtzer-Cabot welcomes inquiries involving special motors

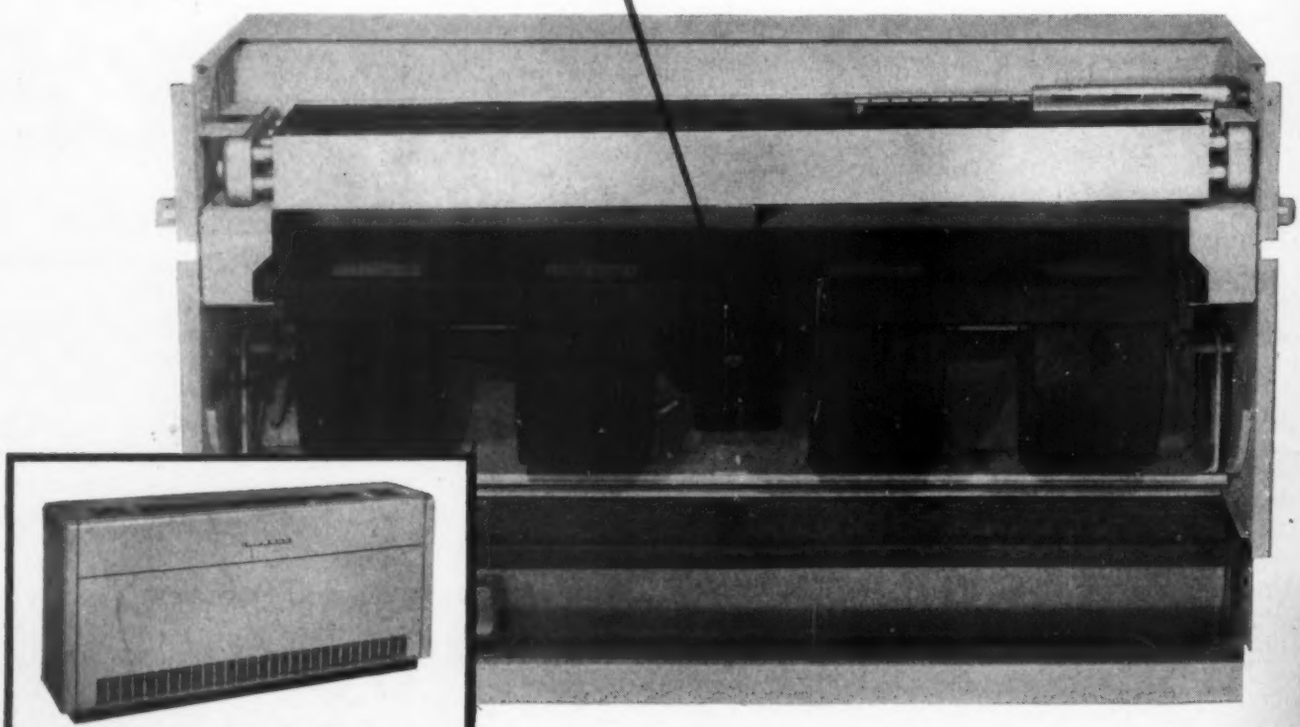
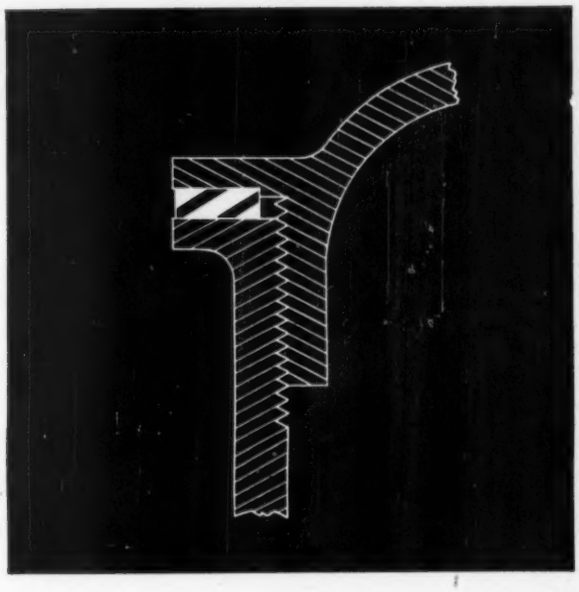


photo courtesy of John J. Nesbitt Co., Inc.



How to design joints for efficient sealing

Wherever you find chronic gasket failure or the forced use of high-cost gaskets, you often find a joint design that makes unreasonable demands on the gasket material.

There are occasions, of course, where inherent factors allow little leeway in joint design. In many cases, however, gasket abuse is caused by joints designed without taking into account the characteristics of the gasket material to be used. Under such circumstances there is always the risk that either sealing economy, sealing efficiency, or both may be sacrificed.

A typical example of this hazard is found in the joint illustrated above. As designed, this joint calls for a gasket that is both soft and hard. It has to be soft to conform to the irregular die-cast flanges; it has to be hard to resist torsion during assembly.

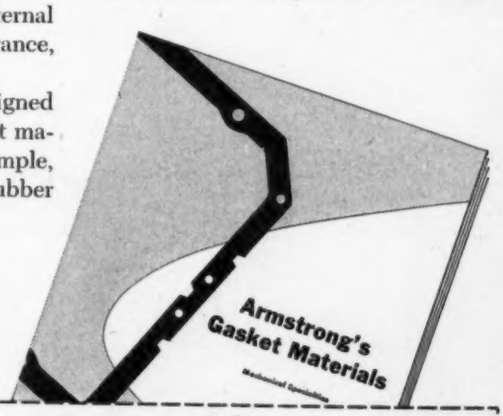
A solution was found by coating an Armstrong's Cork-and-Rubber Composition with a lubricant. It is probable, however, that this seal has a lower margin of safety than is desirable. A better solution would have been to catch this problem when the unit was on the drawing board. Then a joint that put the gasket under direct compression could have been provided, eliminating the need for gaskets with two opposed qualities.

There are a number of things that can be done in the design stage to insure better sealing results. When you know the nature of the solvent or other medium to be sealed, the probable internal pressure, and the approximate bolting pressure involved, you can make a tentative choice of a suitable gasket material. Here your Armstrong representative will be glad to offer suggestions based on his experience with many different sealing problems.

Next, the joint itself should be considered with respect to the needs of the unit of which it is a part. For example, precise alignment of internal parts may dictate a close-tolerance, metal-to-metal flange.

This joint then should be designed on the basis of the type of gasket material initially chosen. If, for example, one of Armstrong's Cork-and-Rubber Compositions has been chosen, the design can be very simple, a channel of the depth and width required by the pressures involved and the hardness or softness of the chosen material. On the other hand, if straight rubber is your choice, either a precision-molded gasket or a relief for side flow may be required, both adding to costs.

All the factors involved in joint and gasket design obviously cannot be covered here. For a more complete discussion of the relation of gasket width to load, the effect of surface condition and of oil on gaskets, practical gasket tolerances, etc., refer to Armstrong's Gasket Materials Manual in Sweet's file for product designers. If you would like a personal copy of the manual, fill in and mail the coupon below.



New Gasket Handbook Now Available

You'll find useful application and specification data in "Armstrong's Gasket Materials." This booklet contains up-to-date information on the various Armstrong's Sealing Materials, plus technical discussions covering many important factors that influence modern joint and gasket design. See Sweet's file for product designers or send coupon for your personal copy.

ARMSTRONG'S
GASKETS • PACKINGS • SEALS

ARMSTRONG CORK COMPANY
Gaskets and Packings Dept.
5112 Arch St., Lancaster, Pa.

Please send me at once a free copy of the new 20-page booklet, "Armstrong's Gasket Materials."

NAME.....
COMPANY.....
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CITY.....STATE.....

For keeping the machines you build in perfect step...

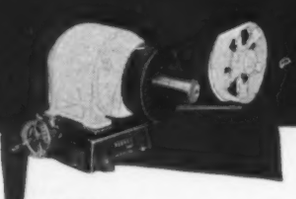
...and in full production at all times...

Reeves Speed Control

accurate!
positive!

Choose from the complete line—REEVES!

Variable Speed Transmission for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Sizes available: fractional to 87 hp.



Vari-Speed Motor Pulley provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. In sizes to 10 hp.

Motodrive combines motor, speed varying mechanism and reduction gears in a single unit. Speed variations 2:1 to 6:1, inclusive. Sizes to 20 hp. (Also available in fractional hp sizes with speed variations to 10:1.)

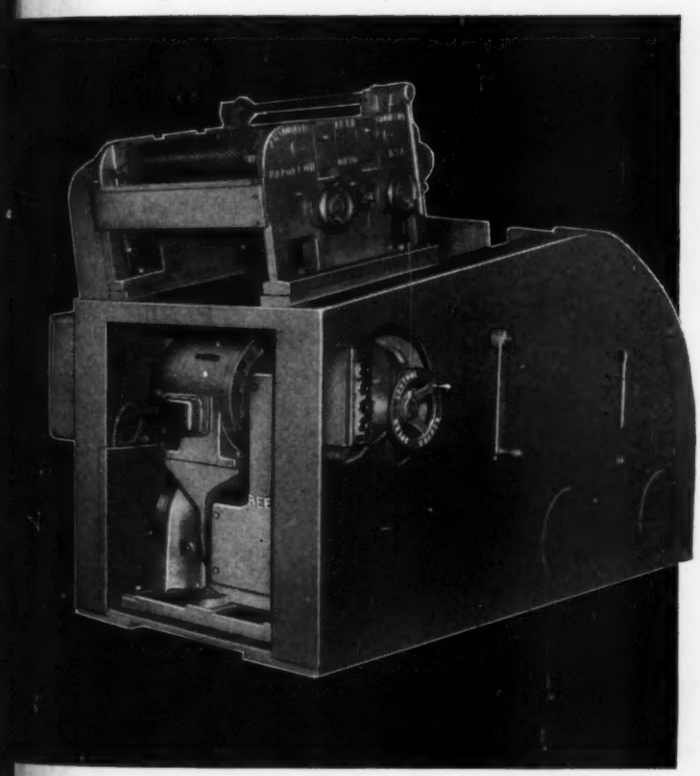
Vari-Speed Jr., a compact, low-cost unit for light machinery. Takes any standard V-belt. Ratios, 1¾:1 to 2¾:1. Sizes—⅓ through 1½ hp.

Who wins the ball games? The team that works together. And who wins the production battles? The manufacturer with the machines and the men that *mesh together* like cogs in a clock.

Synchronization is the word. And that's where accurate, positive REEVES Variable Speed Control fits into your picture as a designer or builder of the new, improved machines your customers are demanding. For *synchronization* is one of the basic and essential functions REEVES does best . . . *precise synchronization* of working parts of one machine or machines operating in series so that production proceeds at the fastest and most profitable pace possible at all times and under all operating conditions.

For *synchronization* or any of the other functions listed below, rely on REEVES—the pioneer and leader—to solve your speed control problem. The REEVES line, now standard equipment on more than 2,100 different makes of machines, is the most complete in the industry—including designs, sizes, capacities, speed ratios and controls to meet the needs of any machine on your production line or on your drawing board.

A REEVES engineer who knows speed control "inside out" will be glad to help you solve your own particular speed control problem, without any obligation on your part. Write for his name and the *free* catalog described below.



Keep from behind the eight-ball—specify Reeves for any of these eight basic functions

1. Handle more sizes, shapes and materials.
2. Match variations in number or skill of operators.
3. Compensate for changes in consistency, density or viscosity of materials in process.
4. Maintain uniform pressure, weight, liquid level, temperature and other variable elements.
5. Maintain uniform peripheral speed (or tension) on decreasing or increasing diameters.
6. Accurately control heating, baking, drying, cooking, cooling or chilling time.
7. Regulate conveyor speeds—even to fractions of an inch per minute.
8. Synchronize all working parts—of one machine or machines operating in series.

Example: REEVES Vari-Speed Motodrive is standard equipment on this Automatic Feed, Cradle and Straightener manufactured by Automatic Feed Company, Napoleon, Ohio. This machine is designed for use on automatic punch presses and, by means of the REEVES unit, its operation is closely synchronized with that of the press. Feed speed is quickly varied to handle different types and thicknesses of material, thus assuring maximum rate of production, minimum number of rejects and uniform quality at all times.

Free!

Write for your copy of comprehensive, 132-page book covering entire REEVES line in detail. Ask for REEVES Catalog H-55-3N.

accurate · variable
REEVES *Speed Control*

REEVES PULLEY COMPANY · COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

Here's what Safety-Circle means to your customers

✓ All-Around Protection

✓ Low Maintenance

✓ Dependable Performance

The SAFETY-CIRCLE

The Allis-Chalmers *Safety-Circle* is the frame and ends of heavy cast iron that completely surround and protect the working parts of the *Safety-Circle* motor.

ALLIS-CHALMERS "Safety-Circle" DESIGNERS' MOTORS

SAFETY-CIRCLE MOTORS are protected all around against those great motor killers—corrosion . . . distortion and friction.

Frames are of cast iron, which *inherently* resists corrosion. The natural strength of cast iron is supplemented by heavy ribbing and bracing . . . has high safety factor to maintain alignment and prevent distortion. Pre-lubricated bearings are packed and sealed at the factory . . . require no attention for years. And, end brackets are drip-proof at no extra cost.

Safety-Circle Motors are fully protected inside, too. Multiple dipped and multiple baked stator windings plus inter-phase insulation provide extra protection against electrical breakdowns.

CERTIFIED SERVICE

Another reason for supplying *Safety-Circle* motors on your equipment. There are 86 service shops to give your customers quick, factory approved parts and service in every major industrial area. Check coupon at right for details. And, when you do specify *Safety-Circle* motors, be sure to order matching Allis-Chalmers controls.

ALLIS-CHALMERS, 1001A SO. 70 ST.
MILWAUKEE, WIS.

Please send me:

Handy Guide for Electric Motors Bulletin 51B6052

Flange Motor Specifications Sheet 51S7234

Safety-Circle Motors Bulletin 51B62108

Name _____

Title _____

Company _____

Street _____

City _____ State _____

A-3166

Safety-Circle is an Allis-Chalmers trademark.

ALLIS-CHALMERS

SOLD AND APPLIED BY AUTHORIZED DEALERS, AND DISTRICT OFFICES THROUGHOUT U. S., SERVICED BY CERTIFIED A-C SERVICE SHOPS

* Does "YEARS" rhyme with "GEARS" for you?

THE HAPPY COINCIDENCE of these rhyming words tempts us to write an advertisement in poetry. But cold business sense sounds better in prose.

The gears you buy should be built to last for years. If they don't—if they require frequent service or replacement—they have a tremendously high final cost, no matter what figures were on the purchase order.

"Double Diamond" gears are built to last for *years*—to produce low installed cost—to serve economically and dependably on the job for which you buy them—and to do credit to your product and your reputation.

Speaking further of years—"Double Diamonds" have been made to these standards since 1914. We would be pleased to enter our 37th year making gears for you. Why not write for more entirely non-poetic information?

DOUBLE DIAMOND
TRADE MARK
GEARS

Automotive Gear Works, Inc.
RICHMOND, INDIANA

• • • • FOR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • •

*Reg. U. S. Pat. Off.

HYPOID BEVEL · SPIRAL BEVEL · FLYWHEEL GEAR · ZEROL* BEVEL · STRAIGHT BEVEL · STRAIGHT SPUR · HELICAL SPUR · SPLINE SHAFT

Further Information?

IF YOU DESIRE MORE INFORMATION ON ANY ADVERTISEMENT IN THIS ISSUE

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Write the name of the advertiser and the page number of the ad in the spaces provided on the card. Check the type of information you want—whether it has to do with price, where you can buy it, or more needed details—or all three, if you wish. After you have finished going through MACHINE DESIGN and have jotted down all the ads on which you'd like more information, just tear off the card and drop it in the mail. No postage is required. We'll have our staff forward this information immediately to the advertiser, so that you will be relieved of the necessity of writing a number of letters. You will then hear directly from the advertiser, answering your request. Because we know that MACHINE DESIGN gets around, and that more than one person sees your copy, we have made up three cards so that if you are one of the later readers, you can still have the opportunity of taking advantage of this service.

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YOUR NAME _____ TITLE _____

COMPANY _____

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CITY _____ STATE _____

MD12-50

FIRST CLASS
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(Sec. 34.9 P.L.&R.)
Cleveland, Ohio

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

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MACHINE DESIGN
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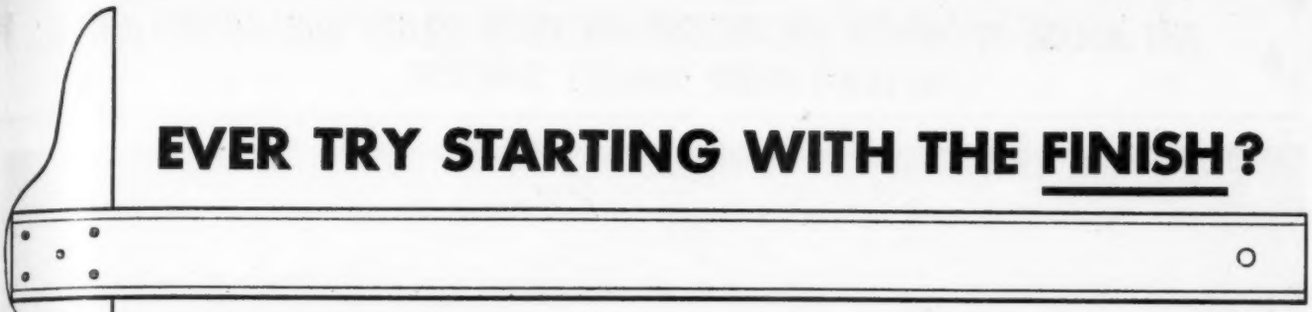
EVER TRY STARTING WITH THE FINISH?



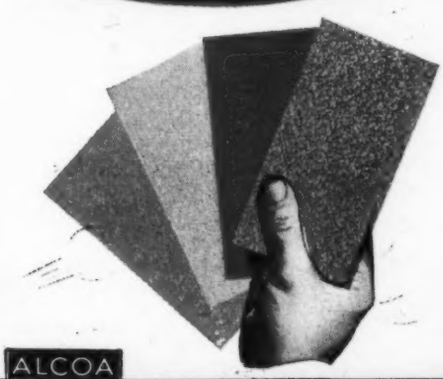
ONE of the interesting things about aluminum is that it can take every type of finish—from simple sand blasting to vitreous enamel, from conventional paints and lacquers to unique anodic coatings possible only with aluminum. And some of these finishes allow spectacular design flexibility. For example . . .

You might be designing a hydraulic system for aircraft. You want light weight cylinders and pistons. But you have greater need for wear resistance. With an anodic coating, you can give these aluminum pistons and cylinders a file-hard surface comparable to hard-chrome plating.

You may be concerned with the cost of a particular finish. Many finishes can be applied right at Alcoa's mills . . . saving you heavy investments in special equipment and manpower. These include Alzak* reflecting surfaces, Alumilite* finishes for gay, built-in color; special anodic coatings for greater corrosion resistance, or high dielectric strength; as well as a variety of decorative mechanical finishes.

An important thing to remember is that such finishes can be obtained on semi-fabricated parts made in Alcoa plants, to Alcoa quality standards, and available to you through a single, dependable source.

*Patented Process



Starting with the finish might prove an important way for you to reduce costs and improve quality. Any Alcoa sales office will be glad to consult with you about it.

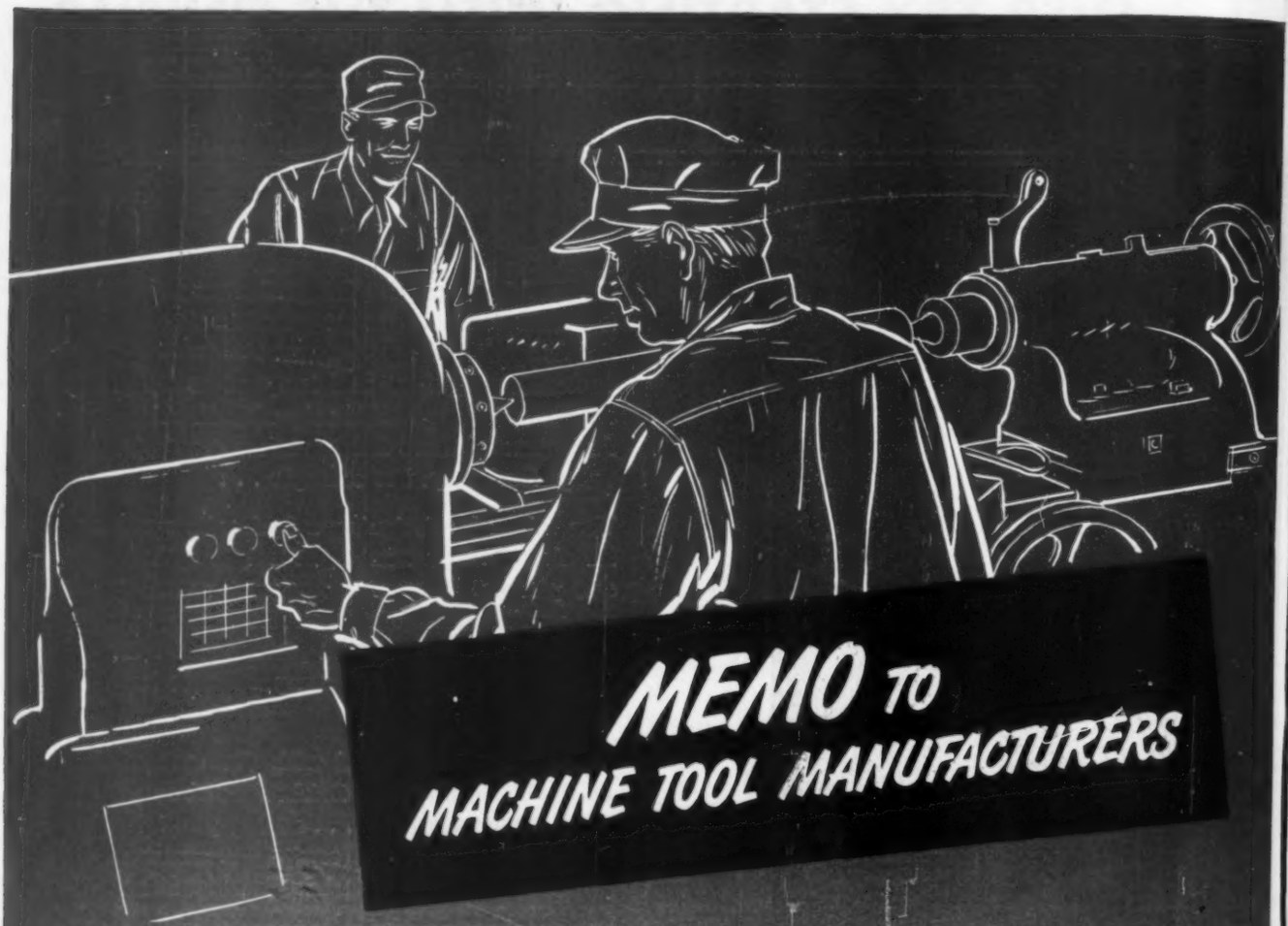
ALCOA

ALCOA

FIRST IN ALUMINUM

In the following pages, Alcoa presents facts for sales designers on representative Alcoa products. On the last page of the Alcoa section will be found the Alcoa offices through which information on aluminum is available. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.

THE ALCOA PRODUCTS ADVERTISED ON THESE PAGES ARE BACKED BY ALCOA'S RIGID QUALITY CONTROL...



MEMO TO MACHINE TOOL MANUFACTURERS

ALCOA ALUMINUM SAVES ON SCREW MACHINE PARTS

Take a screw machine part you now make and figure what you can save by switching to Alcoa Aluminum Stock. You get three times as many parts per pound from aluminum.

Machining costs are the same as brass ... lower than steel. Aluminum requires no finish. But if you want a finish, aluminum takes and holds them all.

Once you see the savings on one part, you'll want to see more. All the information you need is contained in the free book, "Alcoa Aluminum in Automatic Screw Machines". Write ALUMINUM COMPANY OF AMERICA, 2116M Gulf Building, Pittsburgh 19, Pa.

CONTROL BUTTONS

COOLANT NOZZLES AND COUPLINGS

LOCK AND FEED KNOBS

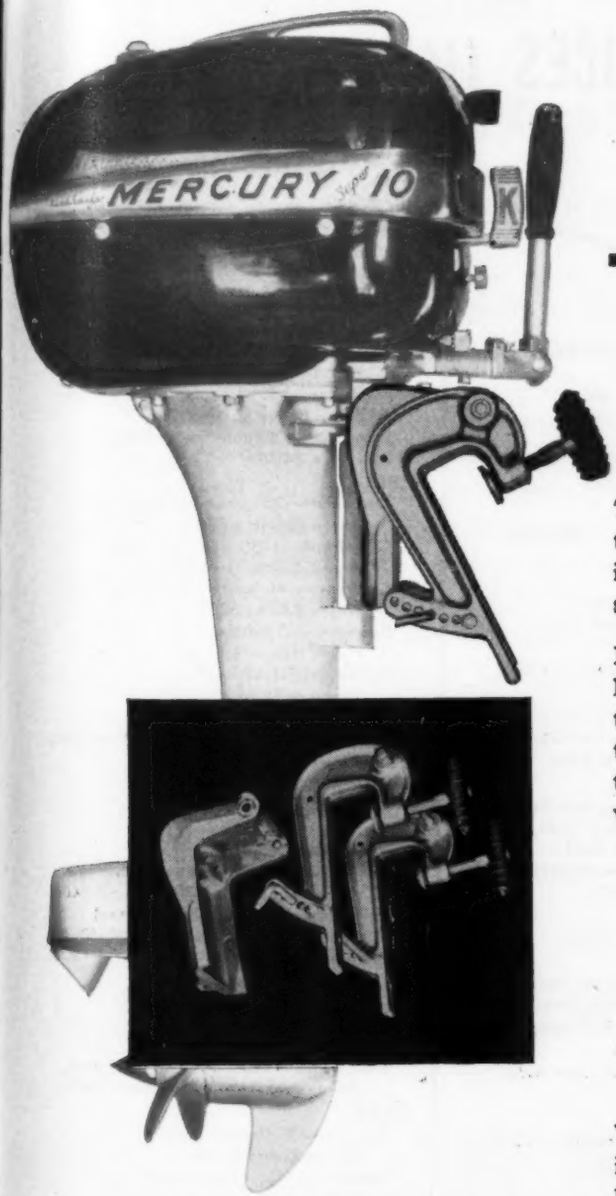
SMALL MULTIPLE PULLEYS

HAND LEVERS

ALCOA *Aluminum* SCREW MACHINE STOCK

ALCOA ALUMINUM

IN ADAPTING THEM TO YOUR USE, YOU ARE INVITED TO MAKE FULL USE OF ALCOA'S OUTSTANDING ENGINEERING HELP



...for Aluminum Forgings
SEE ALCOA

Today's outboard motors are lighter, tougher, more powerful than ever before. Progress in outboarding, as in many other industries, has been achieved through the use of lighter, stronger materials . . . especially at the stress points.

If you are considering aluminum forgings as a way to design light weight and high strength into essential products, talk it over with our engineers. At Alcoa, forging experience teams up with improved facilities and new production techniques to give you quick, economical access to these valuable advantages . . .

- Light weight, combined with forged strength and compactness
- Tough, finely-knit grain structure
- Excellent, uniform physical properties
- Superior machinability
- Attractive appearance
- High resistance to corrosion
- Rapid heat transfer

Write for complete engineering information on Alcoa Forgings for your special application. Or just mail the coupon below. Our forging specialists are ready to work with you. If you would like to receive a copy of the new Alcoa Forgings Manual, please send request on your company letterhead.

ALUMINUM CLAMP AND SWIVEL BRACKET ASSEMBLY introduced on Mercury Outboard Motors in 1950, with phenomenal results... not one instance of breakage reported during entire boating season. Designed by Kiekhaefer Aeromarine Motors, Inc. Forged by Alcoa.

Aluminum Forgings by ALCOA

MAIL COUPON FOR FREE ENGINEERING HELP

ALUMINUM COMPANY OF AMERICA
1807M Gulf Building
Pittsburgh 19, Penna.

Please send me full information on aluminum forgings for the following application:

_____

_____

Name_____ Position_____

Company_____

Address_____

City_____ State_____

THESE ALCOA SALES OFFICES *Will Aid You*

These sources of the Alcoa products (described on the preceding pages) are as near as your telephone. Let them serve you with engineering help, literature, and a pound or a ton of the Alcoa product that best meets your needs.

ALABAMA
Birmingham—505 First National Bldg.
Phone 4-8593

CALIFORNIA
Los Angeles—108 West 6th Street
Phone Tucker 5121
San Francisco—615 Russ Bldg.
Phone Yukon 6-6484

COLORADO
Denver—524 U. S. National Bank Bldg.
Phone Tabor 4638

CONNECTICUT
Fairfield—1333 Post Road
Phone Fairfield 9-5221
Hartford—Capital Bldg., 410 Asylum St.
Phone Hartford 5-2192 to 5-2196

DELAWARE
Wilmington—Delaware Trust Bldg.
Phone Wilmington 8-4138 and 8-4139

FLORIDA
Tampa—1004 Tampa Theatre Bldg.
Phone 2-1984
Miami—1129 Alfred I. Du Pont Bldg.
Phone Miami 9-0651

GEORGIA
Atlanta—1800 Rhodes-Haverty Bldg.
Phone Cypress 4681-2-3-4-5

ILLINOIS
Chicago—520 N. Michigan Ave.
Phone Delaware 7-8181
Peoria—415 Commercial Natl. Bank Bldg.
Phone 3-4224 and 3-1784

INDIANA
Fort Wayne—1935 Lincoln Tower
Phone Eastbrook 4676
Indianapolis—817 Merchants Bank Bldg.
Phone Market 2501
South Bend—805 J. M. S. Bldg.
Phone 2-3333

IOWA
Davenport—503 Kahl Bldg.
Phone 2-6243 and 2-6244

KANSAS
Wichita—411 Fourth Natl. Bank Bldg.
Phone 5-6624

KENTUCKY
Louisville—1154 Starks Bldg.
Phone Wabash 7456 and 7457

LOUISIANA
New Orleans—627 Whitney Bank Bldg.
Phone Canal 3372

MARYLAND
Baltimore—400 Baltimore Life Bldg.
Phone Saratoga 8091 to 8094

MASSACHUSETTS
Boston—20 Providence St., Park Square
Phone Hancock 6-2638, 6-2639, 6-2640, 6-2641, and 6-2694
Springfield—507 Tarbell—Watters Bldg.
Phone Springfield 3-5103

MICHIGAN
Detroit—610 New Center Bldg.
Phone Trinity 1-8100
Grand Rapids—812 Michigan Natl. Bank Bldg., Phone Grand Rapids 9-0209
Jackson—1203 National Bank Bldg.
Phone Jackson 2-8206
Pontiac—301 Pontiac State Bank Bldg.
Phone Pontiac 4-1531

MINNESOTA
Minneapolis—1060 Northwestern Bank Bldg., Phone Atlantic 3528

MISSOURI
Kansas City—2300 Power & Light Bldg.
Phone Victor 3870
St. Louis—10th Floor, Continental Bldg.
Phone Franklin 6700

NEW JERSEY
Newark—744 Broad Street
Phone Market 2-6664

NEW YORK
Albany—90 State Street
Phone 4-0146, 4-0147, 6-7489
Buffalo—1880 Elmwood Avenue
Phone Riverside 2880 to 2884
New York—230 Park Avenue
Phone Murray Hill 6-8046 to 6-8058
Rochester—1331 Lincoln Alliance Bank Bldg., Phone Baker 2630
Syracuse—408 State Tower Bldg.
Phone 3-0156

OHIO
Cincinnati—801 Enquirer Bldg.
Phone Parkway 7700
Cleveland—1450 Terminal Tower
Phone Cherry 1-6880
Columbus—40 South Third Street Bldg.
Phone Adams 5251
Dayton—302 Harries Bldg.
Phone Hemlock 1112
Toledo—1801 Ohio Bldg.
Phone Main 6295

OREGON
Portland—510 The U. S. Natl. Bank Bldg.
Phone Atwater 6605

NORTH CAROLINA
Charlotte—616 Johnston Bldg.
Phone 4-9751

PENNSYLVANIA
Allentown—913 Hamilton Street
Phone Allentown 3-7463 and 3-7464
Philadelphia—123 S. Broad Street
Phone Kingsley 5-0250 to 5-0257
Pittsburgh—2012 Oliver Bldg.
Phone Atlantic 1-4545
York—205 Manufacturers Bldg.
Phone York 2044 and 7441

RHODE ISLAND
Providence—815 Industrial Trust Bldg.
Phone Jackson 1-4108 and 1-4109

TEXAS
Dallas—301 Thomas Bldg.
Phone Riverside 6292
Houston—1806 Commerce Bldg.
Phone Preston 7106

VIRGINIA
Richmond—213 Exchange Bldg.
Phone Richmond 3-8393 and 3-8394

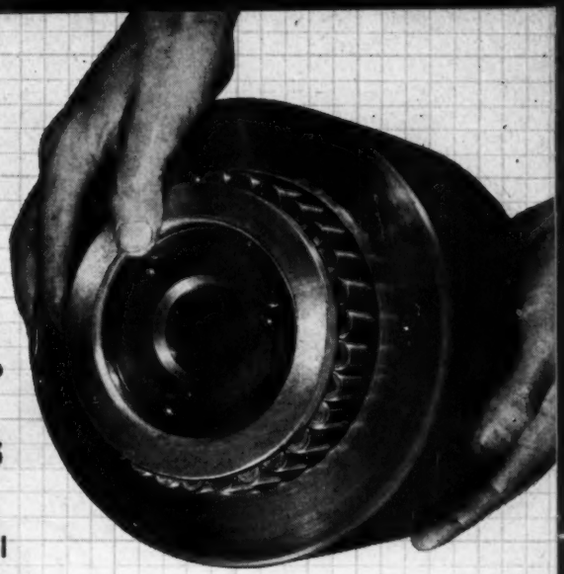
WASHINGTON
Seattle—1411 Fourth Ave. Bldg.
Phone Main 1868

WISCONSIN
Milwaukee—735 N. Water Street
Phone Marquette 8-0185

DISTRICT OF COLUMBIA
Washington—1200 Ring Bldg.
Phone District 9400

ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM ®



when the pressure is on...

USE TORRINGTON BEARINGS

It takes tremendous pressure to reduce cold strip steel 30 to 50% in one pass on thicknesses of .010" and less to close tolerances.

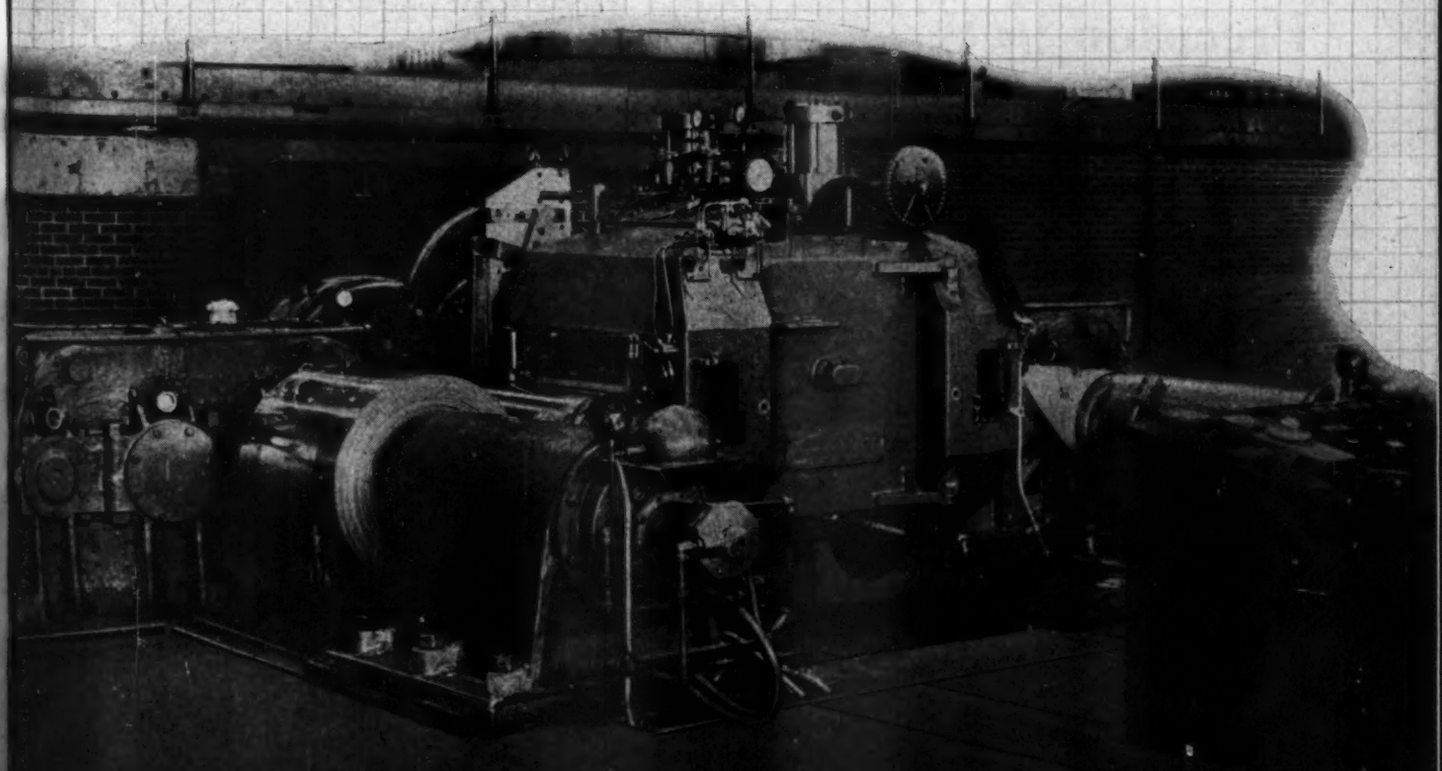
Sendzimir cold strip mills, engineered by Armzen Company, do it by using small diameter work rolls, rigidly backed by precision Torrington Bearings through the intermediate rolls. These bearings carry the tremendous loads and allow the mill to start and stop without resetting the gage.

Your equipment, too, will duplicate such results under heavy working loads if Torrington Bearings are used. Torrington engineers will gladly help you adapt them to your specific requirements.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS

TORRINGTON BEARINGS



Take a bow, fellers!

Precision and quality don't grow on trees. But they grow.

At Keuffel & Esser precision and quality are almost a century plant. In other words they have been growing there in fertile soil for exactly 83 years. (K&E was founded in 1867.)

It's mostly a matter of people. Oh, there are machines, too, big ones, little ones—some of them almost human—but it takes people to imagine the machines, and to master them and supplement them.

Precision in the Air

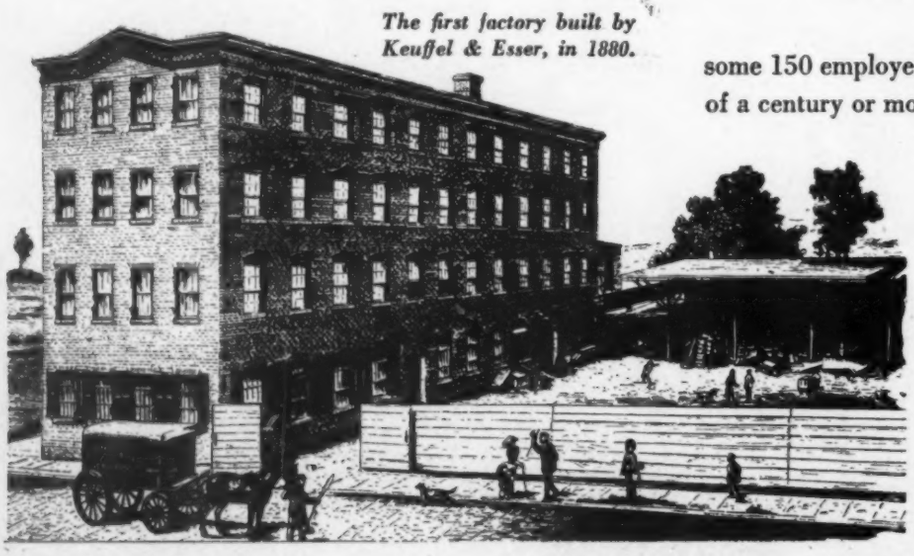
I've been talking about K&E products for a long, long time. Maybe it's time I talked a little about the people behind them.

I've just been through the K&E factory at Hoboken again. I wish you could have been along, because you, as an engineer, would have seen much more than I. But even I could sense the honest craftsmanship and the father-and-son tradition of precision and the zeal for quality in the air.

You just don't get to be that fine in one generation.

There are a number of K&E employees who have been around for about a half a century, and there are some 150 employees who have been there for a quarter of a century or more. This latter bunch of kids, as well as the young sprouts who have been there only 20 or 15 years, have inherited the K&E feeling for doing things the good, old, exciting, honest way.

The first factory built by Keuffel & Esser, in 1880.



But don't get the idea that there is any moss on K&E. An outfit that has thrived this long has to have the knack of remaining perennially young and of keeping ahead of the pack.

"Partners in Creating"

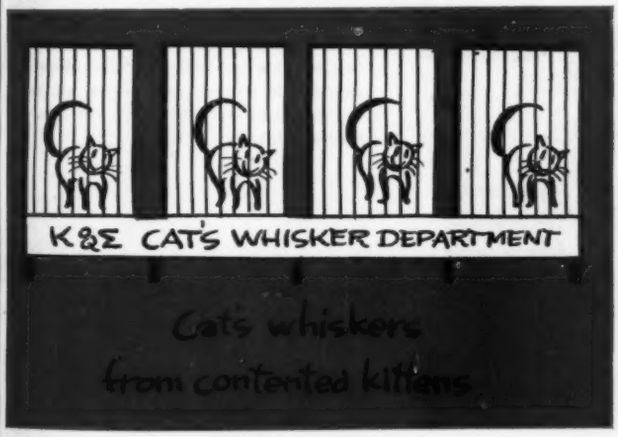
When K&E coined the phrase "Partners in Creating," they of course meant not themselves but their products. And it's true that K&E products have been in with engineers, scientists, draftsmen and architects on the

The K&E trade mark for decades, and the more modern one adopted in recent years.

creation of most of the big man-built wonders of the world for over 4/5 of a century.

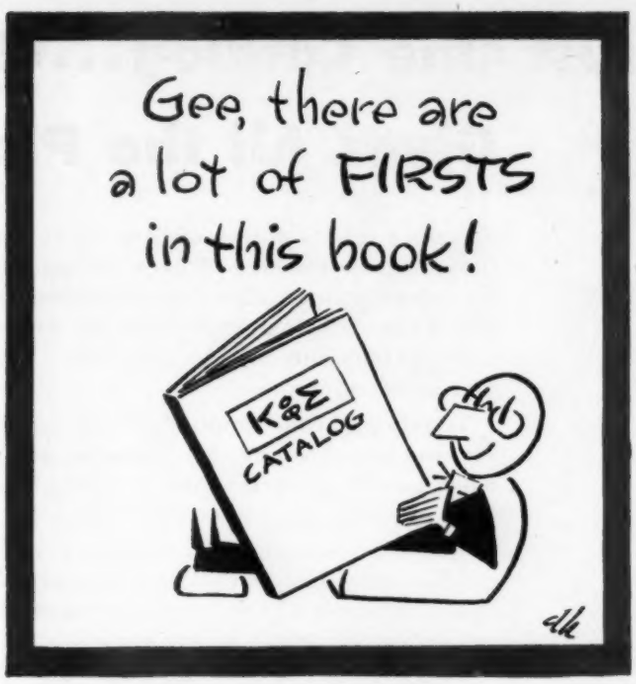
Zippy at 83

K&E have remained alert and alive, as is evidenced by their unending originality and inventiveness. They made America's first slide rules, as far back as 1891. And in both world wars, they did a big development job on optical equipment for our fighting men—on vital things such as periscopes, fire control instruments and height finders. The K&E catalog is full of "firsts"—some of them plenty recent, such as Wyteface* Measuring Tapes and Leroy† Lettering Equipment. No wonder it's the engineers' encyclopedia.



Factories within a Factory

K&E headquarters are a town within a town, many factories within a factory. In one area they're coating miles of papers and cloths. In another they're turning screws so tiny you feel like a hippopotamus if you try to pick one up. Here they're grinding optical lenses.

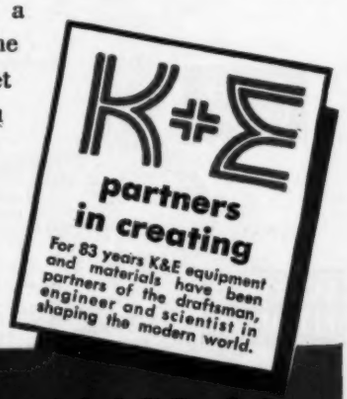


There they're putting graduations no bigger than a fly's kneecap on scales of some sort. Here they're doing fastidiously fine leather work. There they're reeling off steel measuring tapes by the mile.

K&E was in there sighting, in World Wars I and II

But wherever you go you are aware of the age-old passion for precision and quality. And I'm not the least bit sorry that today I haven't sold you a single K&E product. I've just tried a little bit to sell you on the people at K&E—and to get you to believe that you can safely make K&E products trusted partners in your own creative work.

*Trade Mark
†Trade Mark ®



KEUFFEL & ESSER CO.

Just One Catalog...CRANE
Gives All the Piping Specs

To take a case in point: suppose you're designing the *Steam Generator,* shown here. What's the quickest way to find all the valves, fittings, pipe and accessories you need? Turn to your Crane Catalog. It contains the world's most complete selection of quality piping equipment . . . helps cut specifying time to the minimum.

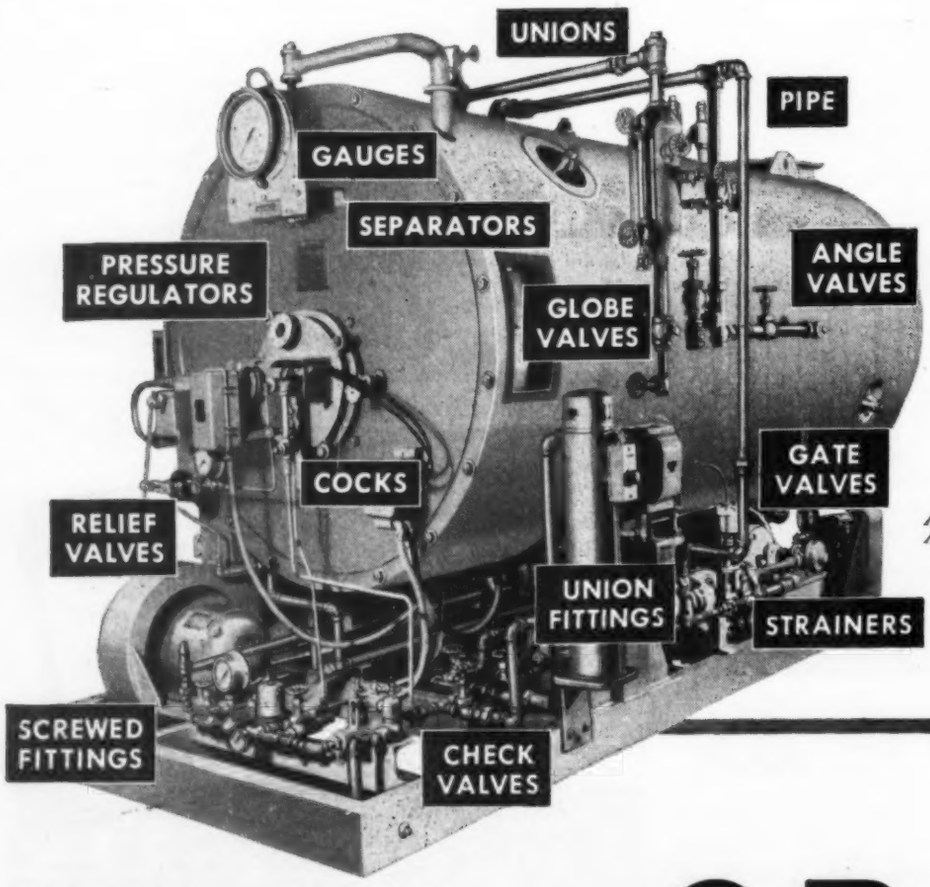
To rely on Crane simplifies all piping procedures. Ordering and storekeeping, for example, are greatly simplified when you can get everything in piping from a single source. Shop assembly goes smoother, too.

Most important to you, of course, is the added value your product acquires when all flow control equipment is Crane. Your customers know from experience that Crane Quality stands for the best in piping materials.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

FOR THROTTLING and other severe services such as blow-off, boiler feed, drip and drain lines, Crane recommends No. 16½P 150-Pound Brass Angle Valves. Crane alloy plug type disc and seat permit close regulation of flow; offer higher resistance to wire-drawing, corrosion, erosion, galling and scoring. Union or bolted bonnet, depending on size. Working pressures: 150 pounds saturated steam; 300 pounds cold water, oil, gas. Sizes: ⅛ to 3-inch. See your No. 49 Crane Catalog.

● FOR BETTER SELECTION EVERY TIME
. . . LOOK TO THE COMPLETE CRANE LINE



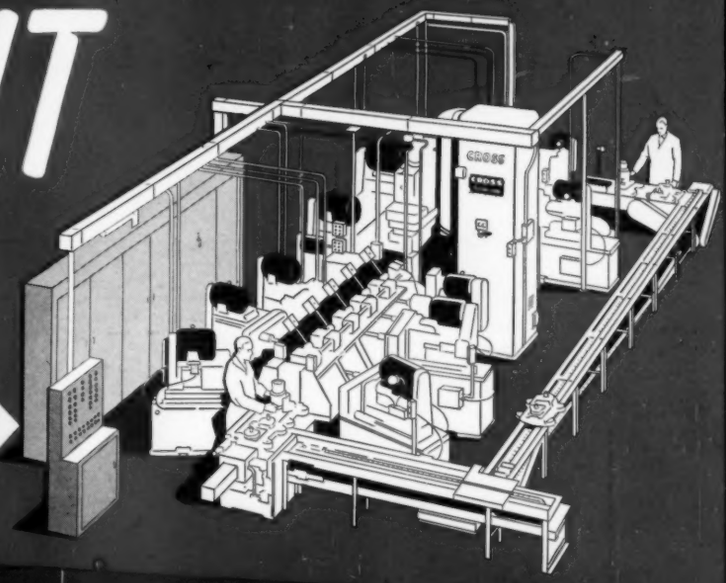
Amesteam Generator by Ames Iron Works, Oswego, N. Y.

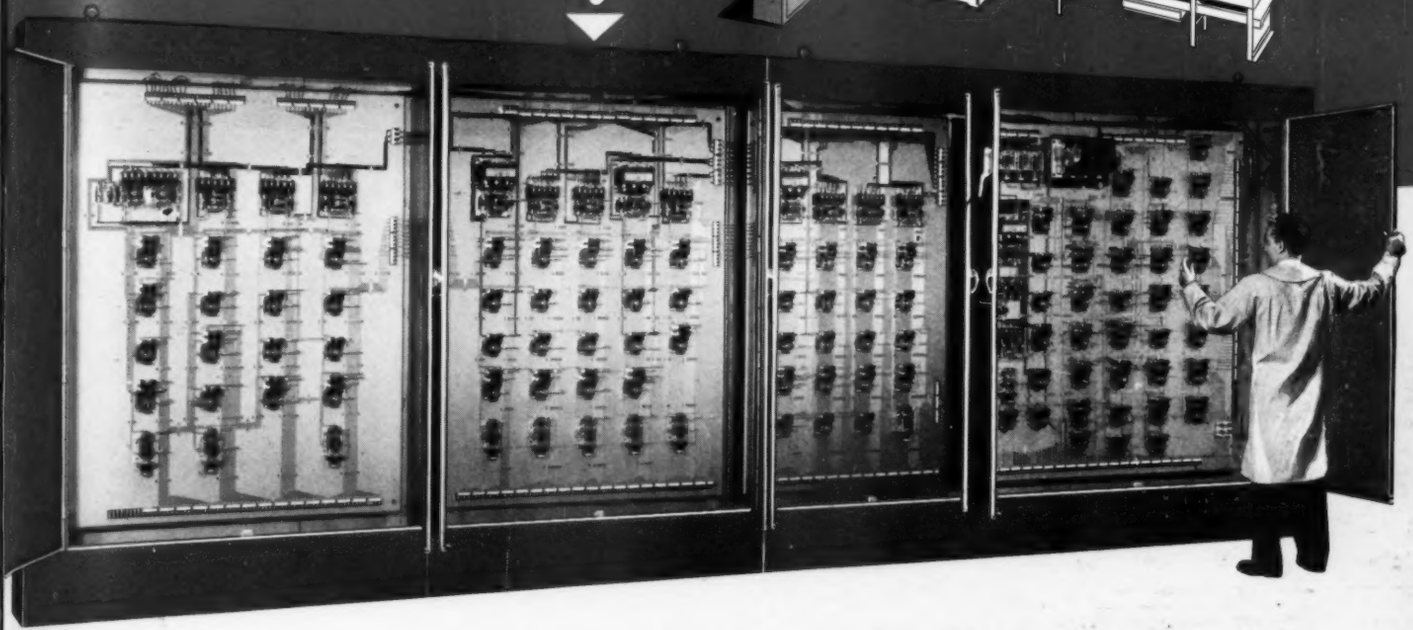
EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

120 UNIT CONTROL PANEL . . .

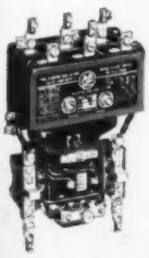




Panel Components

Bulletin 700 solenoid relay ... dependable ... consistent ... in closing and opening time.

Bulletin 709, Size 0, open type solenoid starter. Simple design assures trouble free operation.



Bulletin 709, Size 2, open type solenoid starter. A-B control is known for its reliable motor overload protection.

...integrates the operating sequence of this huge production machine...

This marvel of complete automatic operation . . . is the Cross Transfer-Matic Machine for machining automobile transmission cases.

Over one hundred individual operations are co-ordinated into an automatic machining sequence. Obviously, split second, trouble free operation of the control is essential to justify the cost of such a machine.

All Allen-Bradley solenoid contactors on this control board have but one moving part. There are no links, levers, pins, pivots, or bearings to corrode, stick, or affect the time of operation. Such simplicity guarantees trouble free performance.

The overwhelming preference of machine tool builders for Allen-Bradley controls is easy to explain. No other controls are so trouble free. Descriptive bulletin will be mailed on request.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

A-B Quality

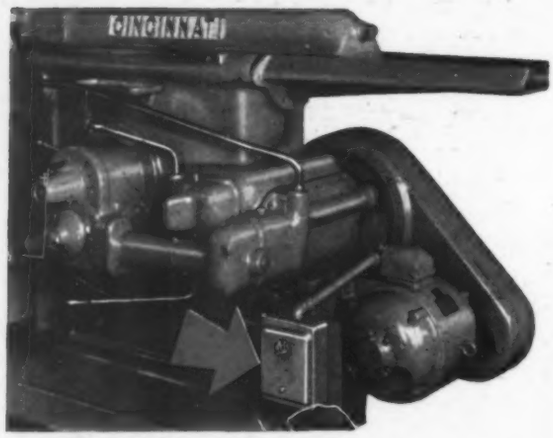
ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

750-R

TROUBLE FREE CONTROLS

FOR SIMPLE OR COMPLEX SEQUENCE OPERATIONS



SINGLE MOTOR DRIVES—The Cincinnati Shaper Company furnishes, as standard factory equipment on these machines, an Allen-Bradley solenoid starter with a Start and Stop push button station near the operator. While this is a simple, one motor drive, the Allen-Bradley Bulletin 709 starter does more than merely start and stop the motor.

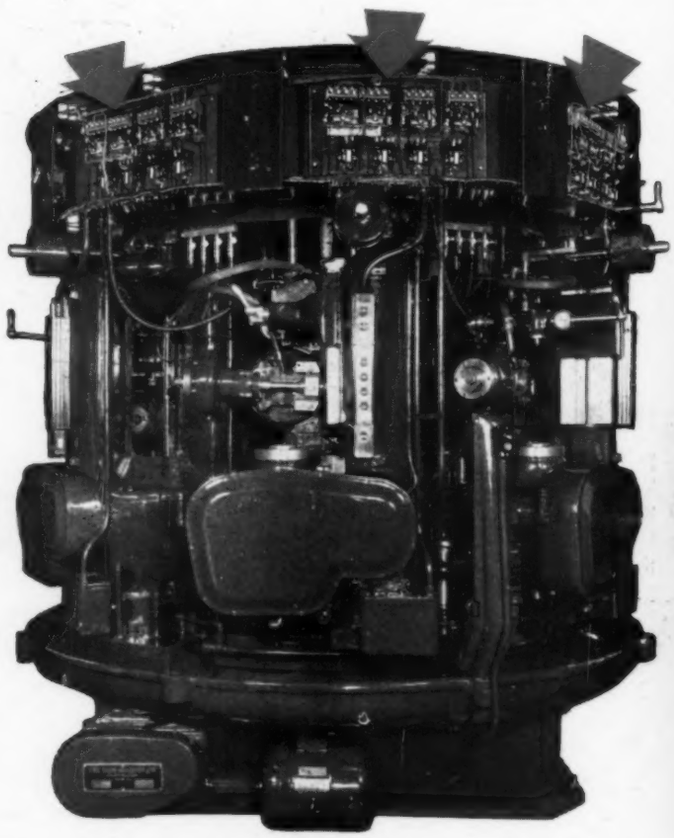
Accurate and dependable overload protection is provided by two Resistotherm overload relays in the starter. White interior makes inspection easier.

The "no voltage" protective feature of these starters prevents the motor and machine from re-starting accidentally after line or fuse failure.

Complete protection is assured for man, motor, and machine at all times.

Keen machinery designers take full advantage of the precision performance and dependability of Allen-Bradley motor controls. The consistent timing of opening and closing provides precision co-ordination of machining operations. The result is increased output without loss of safety.

Let us show you, without obligation, how to use solenoid controls on your machines to best advantage.



MULTI-MOTOR DRIVES—Lees-Bradner Company of Cleveland, Ohio, designed this 8-spindle gear hobbing machine with 27 electric motors. This automatic rotary tool required a complex system of automatic sequence controls. In the illustration, above, are shown some of the control panels around the top of the machine. The total control system required 118 Allen-Bradley starters, relays, limit switches, and push buttons.

Leading machine tool builders have standardized on Allen-Bradley solenoid controls, because they are so dependable and trouble free.

Allen-Bradley motor starters are available in various enclosures such as general purpose, water-tight, dust tight.

Allen-Bradley switches and starters are self insulated, and can be grouped closely in gangs on metal panels or in machine bases.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. 750-R

A-B Quality

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

The Magic Touch that Increases Sales!

The Ekotape Pla-mate (Model 109) manufactured by Webster Electric Co., Racine, Wis., on which the die castings illustrated are standard equipment.

Proper Material Selection gets close attention by the technical staff at Webster Electric. After the careful screening of all possibilities they decided on Madison-Kipp die castings for strength, lightness, eye appeal and value.

When you plan new products requiring metal parts, please keep us in mind. Please also remember to send full data to our home office in Madison.

MADISON-KIPP CORPORATION

210 WAUBESA STREET, MADISON 10, WIS., U.S.A.

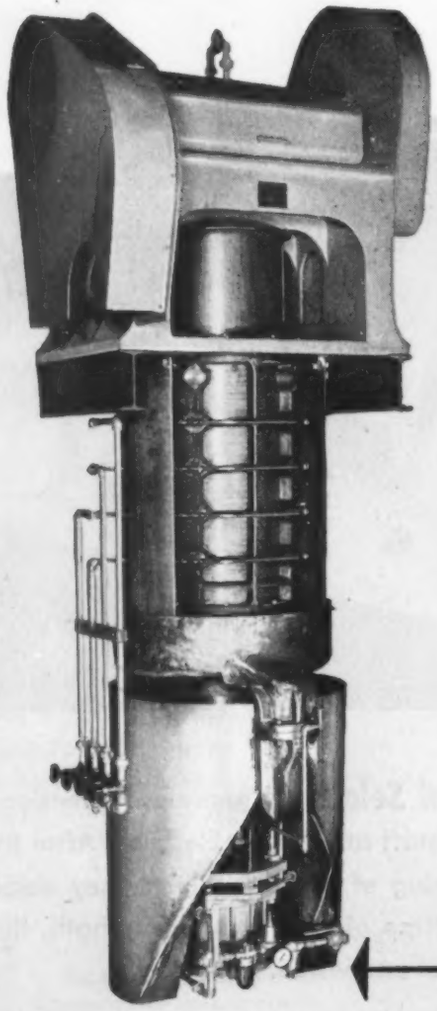
ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

Norgren units help put *Continuous* in

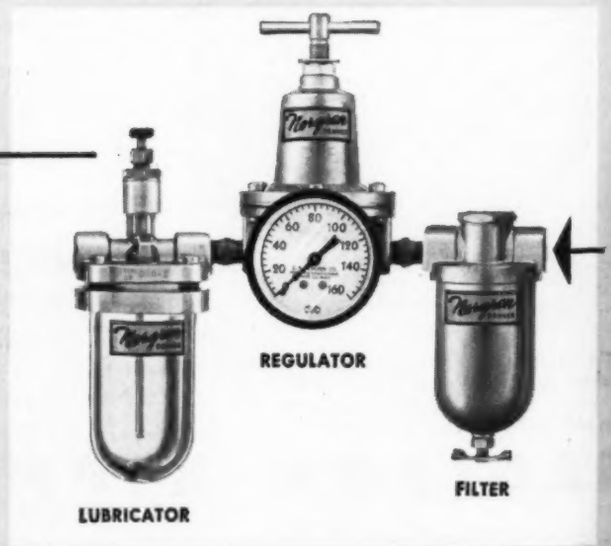
JACKSON & CHURCH CONTINUOUS PULP PRESSES



An air-controlled FLOATING CONE beneath a vertical screw-type press-spindle automatically maintains a a pre-selected constant counter pressure against the force of the pulp feed, ***regardless of the rate of feed.*** Results: higher liquid separation; greater recovery yield of marketable by-products; no overloading; no attention required.

J & C selected the Relieving Type Norgren Pressure Regulator with its sensitive and accurate air regulation to give automatic and continuous control over the performance of their "Zenith" pulp press. Customers report no servicing required even after years of 24-hour service—much of it 7 days a week. Simple in design—rugged in construction and remarkably efficient in operation.

The Norgren Lubro-Control Unit includes Air Filter, Regulator and Lubricator. Filtered air prevents scored cylinders and damaged packings. Norgren oil fog lubrication of the cylinder is assured by simply operating the cylinder over its full 6" stroke several times, once a week —replacing inefficient, manual lubrication and improving cylinder performance and life.



MORAL When YOU have special problems demanding cleaner, better regulated air power and automatic lubrication of air powered equipment—CHECK WITH NORGREN.

Get all the details described in Norgren Blueprint #104. Write C. A. Norgren Co., 242 Santa Fe Drive, Denver 9, Colo.

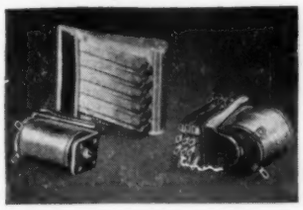
Norgren

Filters, Regulators, Lubricators, Valves, Hose Assemblies

Ask for this 88-page technical guide to the use of relays and switches

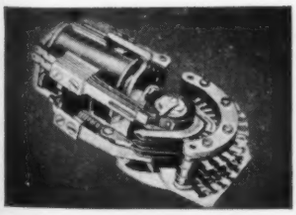
relays

Class "B" Relays—For extremely high speed operation and for time delays on either "operate" or "release" strokes. Available for either d-c or a-c operation.

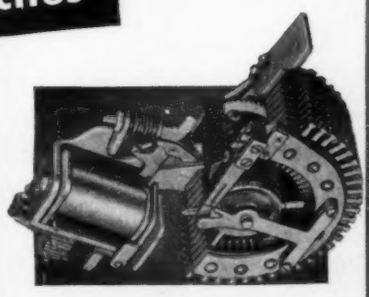


Class "S" Relays—Astonishing power in a small, light weight relay. Hermetically sealed if desired. Unaffected by vibration, temperature, humidity. Coils up to 10,000 ohms or more.

switches



Type 44 Stepping Switch—For d-c operation, tiny, light weight. Accommodates up to 6 bank levels with 10 points plus "home." Adaptable to 10-, 20- or 30-point operation.



Type 45 Stepping Switch—For d-c operation, or supplied with built-in rectifier for a-c operation. Accommodates up to 10 or more bank levels. Adaptable to 25- or 50-point selection.

AUTOMATIC ELECTRIC
CHICAGO

Catalog No. 4071-F

For any product — for any purpose where you need relays or stepping switches—there is an Automatic Electric unit that's exactly RIGHT. Only a few are shown at the left, but all are illustrated and described in our big new catalog 4071-F.

Here are complete specifications and performance and mounting data on the wide range of components manufactured by Automatic Electric Company for communication, signaling, and industrial electrical control service. Here you'll find units for *your* jobs—including hermetically sealed and low-capacitance relays, and the most compact stepping switch on the market! Write for your copy of this new catalog. Address: AUTOMATIC ELECTRIC SALES CORPORATION, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric (Canada) Ltd., Toronto. *Offices in Principal Cities.*

Automatic Electric Sales Corporation
1033 West Van Buren Street
Chicago 7, Illinois

Gentlemen:
Please send me a copy of Catalog No. 4071-F. I am attaching my business letterhead and address.

Name _____
Title _____
Company _____

TORQUE AT ZERO SLIP

...plus 7 other outstanding clutch advantages with a VICKERS Magneclutch*

Illustrated is a Magneclutch designed for high power slip service.

NEVER BEFORE in clutch history has *one* product offered all these design and operating features! Check them against your clutch requirements for SLIP SERVICE... BRAKING... ON-OFF or TORQUE SERVICE... TORQUE LIMITING... REVERSING DUTY.

Dry magnetic torque medium
Large maximum to minimum torque ratio
Virtually no wear on torque transmitting surfaces
Fast response
Small control power
Easily adapted to remote control
Electrically controlled

WRITE FOR BULLETIN 6000... it gives complete facts on the MAGNECLUTCH. Please make request on your letterhead.

VICKERS ELECTRIC DIVISION

VICKERS Inc.

1701 LOCUST STREET ST. LOUIS 3, MISSOURI

LINDE'S News of Metalworking

$$$$$$ Saved in Removal of Blast-Furnace Salamander

Oxy-acetylene powder-cutting eliminated a nasty job in one steel mill not long ago. The problem was to remove a salamander in a blast furnace so that the hearth could be replaced without disturbing the upper lining.

After discussing the problem with a LINDE Process Service representative, the company decided to use powder-cutting with an OXWELD C-60 Blowpipe to cut up the salamander.

Only three days were required for the cutting. Production time saved over any other removal method was estimated to be two weeks. $500,000 worth of iron can be produced in two weeks' time.

Most important from the mill's standpoint was the fact that the upper brickwork was not damaged. Damage from other methods of removing the salamander could run as high as $300,000 worth of brickwork.

The OXWELD C-60 Blowpipe is specially designed for extra heavy cutting. And when powder-cutting is used refractory oxides are no problem.

What's News

► Of special interest to quarry men is LINDE'S Jet-Piercing blowpipe which can pierce holes to a depth of 5 ft. in hard and abrasive rocks and ores. This economical, speedy method makes blast holes in granite at a rate of 22 to 25 ft. per hour.

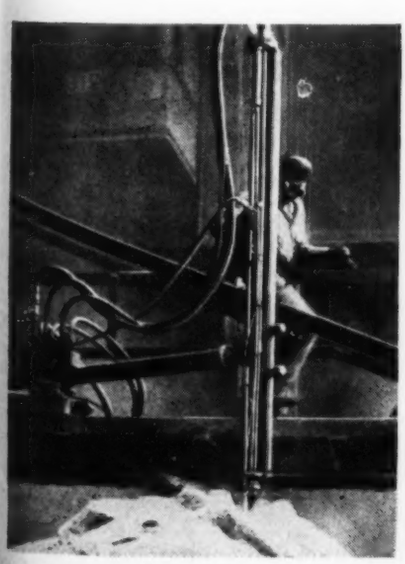
► One pipe manufacturer has produced a record seventy miles of 24-in. pipe (12,990 tons) in one month with the help of UNIONMELT welding.

► By using oxy-acetylene flame-cleaning, a foundry has cut the time required to clean slag from the center of their 20-in. castings from about 6 hours to 5 minutes.

► When television inspectors rejected ten thousand tubes because of cracks in the spun chrome steel bases, LINDE engineers showed the tube manufacturer how to make repairs by HELIARC welding. A saving of $8.00 per tube was accomplished.

LINDE Service Doesn't Cost -- It Pays!

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto



Powder-cutting is used for many jobs in addition to the salamander cutting described above. It is ideal for reducing large masses of cast iron.

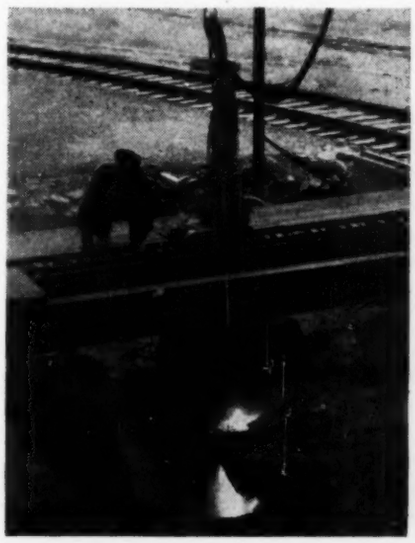
"Lost Heat" Reclaimed in 18 Hours

When a full 75-ton heat of steel was recently lost through the bottom of an open-hearth furnace, it was reclaimed in only 18 hours. An OXWELD C-60 Cutting Blowpipe quickly cut the metal to handling size. Using older methods this would have been a three-day task.

Two full days of operating time were saved by returning the furnace to service in 18 hours. Actual cutting time was only five hours.

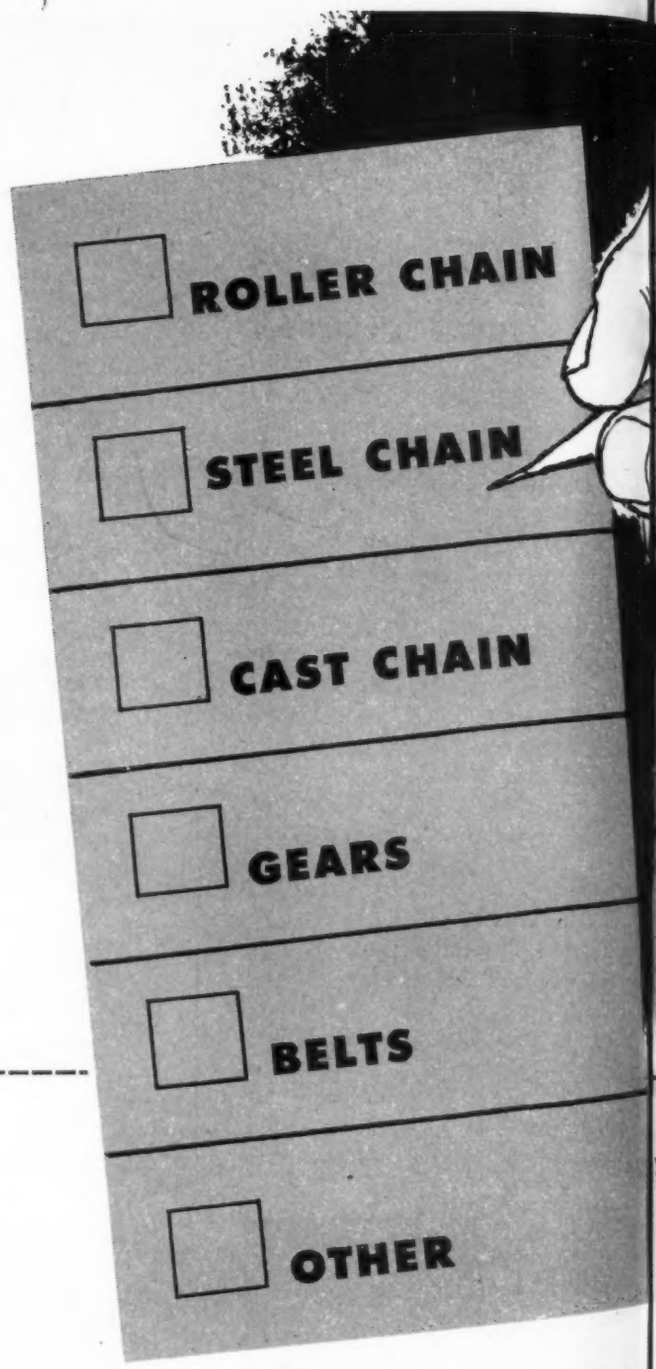
And the expense? Total cost for materials amounted to not more than $100.

For further information about powder-cutting or other LINDE processes, call or write our nearest office. We'll be glad to give you more details.



Slag and cinder inclusions are no problem for the C-60 and powder-cutting. Spill sections as thick as 6 ft. have been severed by continuous cutting.

The terms "Linde," "Oxweld," "Unionmelt," and "Heliarc" are registered trade-marks of Union Carbide and Carbon Corporation or its Units.



Have you made the right choice?

. . . if you're designing for lower cost!

Let's consider your power transmission equipment. You know that substantial savings in first cost . . . in operating cost . . . in overall cost can be realized through proper selection and application of power transmission equipment in your machines.

There is no one best method for all equipment. BUT there is a *right* answer to *each* machine for driving, timing and conveying. In the complete Chain Belt line, you can find an answer to the vast majority of applications. Because they are not handicapped by the limitations of a limited line, Rex Field Sales Engineers can help you select the exact type of chain that is right for your machines . . . for lower costs all along the line.

Perhaps you have been using a finished roller chain, yet speed and load conditions are such that a cast chain or double-pitch roller chain will operate equally well at lower initial costs.

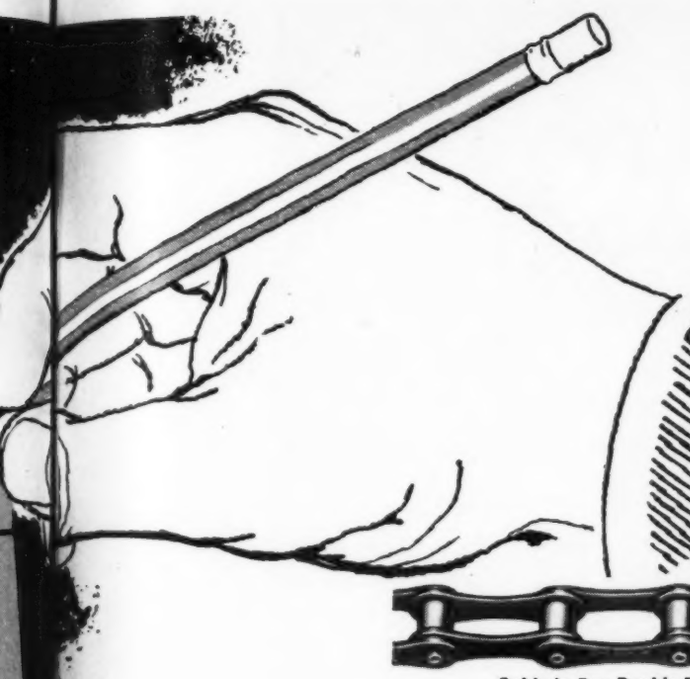
Perhaps you have been using a cast chain, yet speed requirements demand a roller chain for efficient operation. It may be that your machine demands exact timing *throughout its life.* Only finished roller chain will answer this need.

Your equipment may be required to operate in dusty, dirty conditions. Chabelco Steel Chain can save you and your customers money here.

You may be using too heavy a chain for the service conditions under which your machine is to operate. The Rex Man will help you select the right chain that will do the job effectively at lower cost.

The complete Chain Belt line provides a chain to exactly suit virtually every application. In those instances where belts or gears may be better, the Rex Field Sales Engineer can tell you why you should use these mediums for best results.

Chain Belt Company OF MILWAUKEE

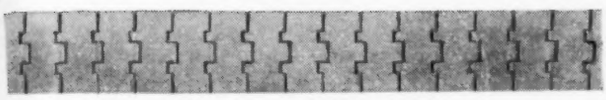


Baldwin-Rex Standard Roller Chain

Rex Cast Pintle Chain

Baldwin-Rex Double Pitch Roller Chain

Rex Chabelco Steel Chain



Rex TableTop® Conveyor Chain

Baldwin-Rex Leaf Chain

Your Rex Field Sales Engineer will be happy to consult with you regarding your application problems. He may be able to help you make substantial savings. Call or write your nearest Field Sales Office. Or, if you prefer, mail the coupon.

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PUT THIS New Low Cost IMO ON YOUR OIL LINES!

I-161R

Now you can have all the advantages of the IMO: high speed operation—quietness—freedom from vibration—simplicity—reliability—at less cost than ever before.

Look at the cross-section and you will see why no other pump is quite so well suited for oil handling service.

The axial flow design permits oil to be pumped close to the rotating axis of the rotors. This means low liquid velocity and quiet operation at high speeds.

Large inlet areas provide smooth entrance of liquid into the pump and permit the handling of high viscosities at high suction lifts.

The A313A IMO has no stuffing boxes to leak or require packing, and best of all, it can be mounted in any position and be directly connected for operation at motor speeds.

For your next oil handling job, be sure of the best . . . specify the new low cost A313A IMO pump. Ask for Bulletin I-161R-D.

IMO-DE LAVAL PRODUCTS DIVISION

DeLaval Steam Turbine Company, Trenton 2, New Jersey

DE LAVAL

stainless steel is a family affair

There's more than just one type of stainless steel . . . because *stainless* applies to a family of steels. And in order to get the best possible results from stainless in your application, the *right* analysis must be used.

That's why Crucible, a pioneer in the development of this specialty, offers you the services of an alert staff of metallurgists to help you with your stainless application problem.

Crucible's half century of specialty steel leadership is built on a strong foundation of service to Industry . . . with attention to detail . . . whether the order is in tons or pounds. From the ground up, Crucible designed and put into operation one of the first integrated mills built specifically to hot and cold roll stainless steel. This $18,000,000 addition gives Crucible facilities to provide industry with stainless in every form.

There is no substitute for Crucible's background of 50 years of specialty experience. Let Crucible show you how to apply stainless steels to your products. One call from you puts us to work on your application.

CRUCIBLE STEEL COMPANY OF AMERICA, Chrysler Building, New York 17, N. Y.

CRUCIBLE first name in special purpose steels

STAINLESS STEELS

STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE • STEELS

Will Gladly Accept your Order...

Subject to a Great Big IF

Engineering knowledge, tooling, and production know-how, coupled with the most modern equipment available, are what it takes to produce quality parts made from metal powders—and Moraine has all these in full measure. Naturally, we seek your order, provided we are convinced that the metal powder process will work to *your* advantage—in lowered costs and better performance.

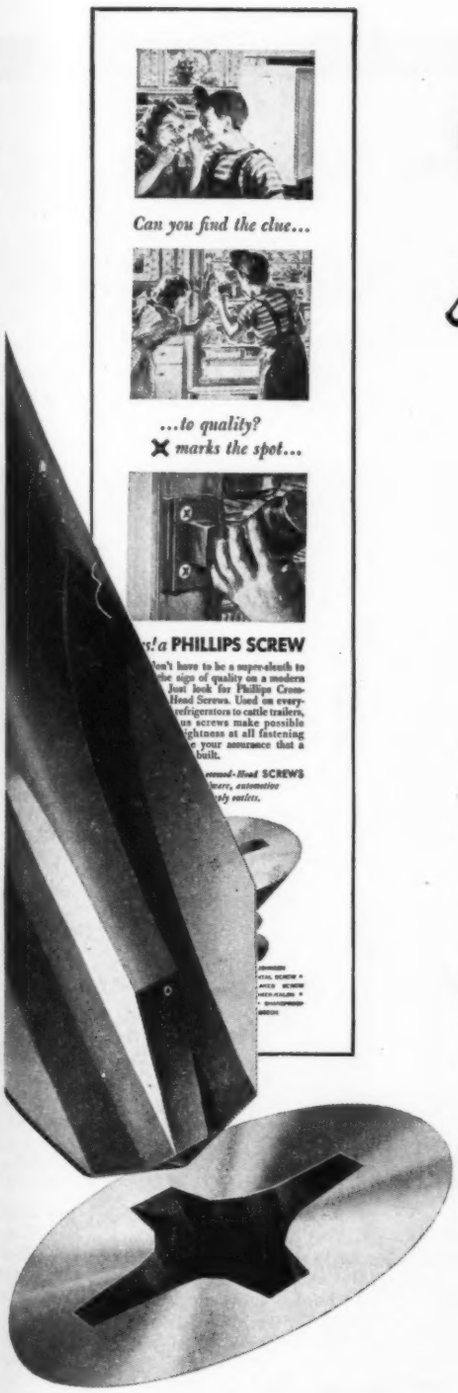
Ask Moraine whether parts you are using can advantageously be produced by powder metallurgy. We'll gladly accept your order—

- **IF** the shape of the part permits good die fill and correct density . . .
- **IF** its required physical properties and tolerances can be obtained by our normal production methods . . . *and*
- **IF** it is to be made in quantities sufficient to justify tooling costs, set-up, and equipment loading.

Those are the three big IF's . . . and here's another just as important: IF we accept your order, you can be sure, in advance of delivery, that Moraine parts will justify your interest and may reduce your manufacturing costs.

METAL POWDER PARTS BY MORAINE

MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS
DAYTON, OHIO



Does your product have this clue to quality?

Use of Phillips Screws proves extra care in manufacture

Production men know. Design engineers know. Purchasing agents know. AND NOW THE PUBLIC KNOWS that . . .

X marks the spot . . . the mark of *extra* quality. The identifying X formed by the cross-recess on the head of every Phillips Screw.

14 million readers of The Saturday Evening Post are being urged to look for this clue to quality in modern, well-built products.

Phillips Screws make your product stronger, better looking. They eliminate jagged burrs, split screw heads, make production power driving possible. Whether you use Phillips wood screws, machine screws or tapping screws you gain time, money, work-hours.

◀ Current advertisement on Phillips Screws appearing in The Saturday Evening Post.

PHILLIPS *Cross-Recessed-Head* **SCREWS**

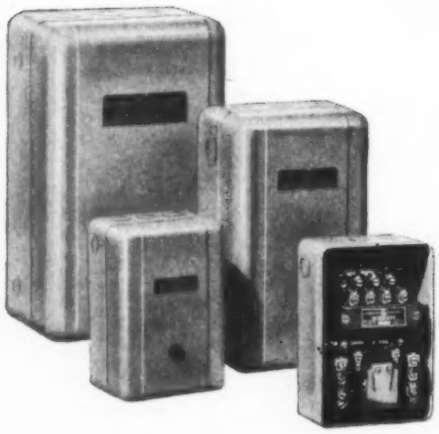
X marks the spot . . . the mark of extra quality

AMERICAN SCREW CO. • THE BLAKE & JOHNSON CO. • CAMCAR SCREW & MFG. CORP.
CENTRAL SCREW CO. • CONTINENTAL SCREW CO. • ELCO TOOL & SCREW CORP.
GREAT LAKES SCREW CORP. • THE H. M. HARPER CO. • NATIONAL LOCK CO. • PARKER-KALON CORP.
PHEOLL MANUFACTURING CO. • ROCKFORD SCREW PRODUCTS CO. • SCOVILL MANUFACTURING CO.
SHAKEPROOF INC. • THE SOUTHINGTON HDWE. MFG. CO. • WALES-BEECH CORP.

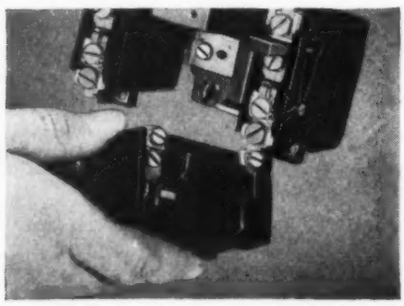
THE FASTENERS OF TODAY . . . AND OF THE FUTURE

Designer's

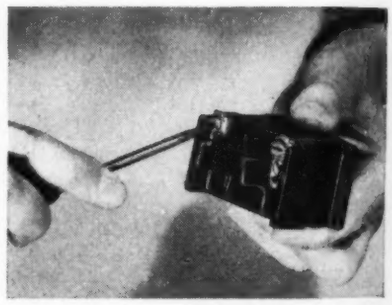
IN DEMAND—because they last longer!



One thing your machinery customers want in a starter is long life and without expensive maintenance, too. That's why they prefer General Electric a-c magnetic starters, built to last longer than any other you can buy! Get the full story in Bulletin GEA-5153.



1 **Note the coil!** It's the G-E "strongbox" magnet coil, two to five times longer-lasting than conventional coils. Windings can't be damaged by a slipping screwdriver because they're locked in a molded plastic block.



2 **Note the terminals!** Permanently anchored in the coil enclosure, they can't work loose, even after years of operation. And note, too, that they're located on the front of the coil. Makes servicing easier, faster.

3 **Note the magnet!** Even after it's been in service for years, it moves smoothly back and forth, thanks to the permanent "molded-in" lubricant in the plastic coil block. There's no metal-to-metal friction, no bearings to wear.

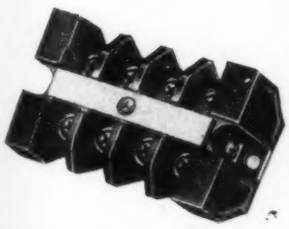
4 **Note the contacts!** Made of fine silver, they'll stand up even in toughest "start-stop" service. High initial tip pressure leaves little chance of their welding together. And arc hoods keep each tip protected.

Motor Starters

GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS



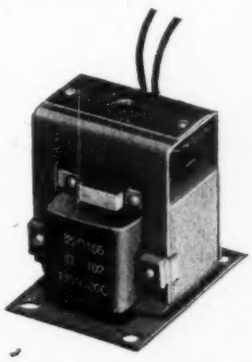
NEW TERMINAL BOARD

—to simplify control wiring

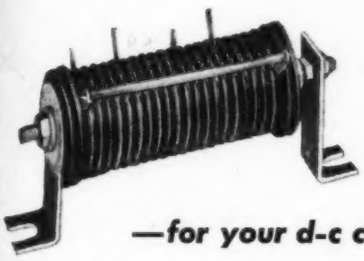
This new General Electric EB-5 fabricated terminal board has washer-head connection screws to speed the job of wiring, testing and checking your circuits. Rated 600 volts, 30 amperes, it's made in 4-, 6-, 8-, and 12-terminal units, to accommodate wire sizes AWG 18 to 10. Reversible, black-and-white plastic marking strips facilitate wire identification. See Bulletin GEA-1497.

SHORT-STROKE SOLENOIDS

—with long-life features



Here's a new General Electric push-type solenoid—for strokes up to $\frac{1}{16}$ inch—built for long life under heavy pounding and rapid duty-cycle operation. One reason for its durability is the rock-hard plastic block encasing the coil and protecting it against moisture, oil, shock and vibration. Others include new riveted magnet structure, stainless steel backstop, and heavy, brazed-on baseplate. See Bulletin GEC-692.



METALLIC RECTIFIERS

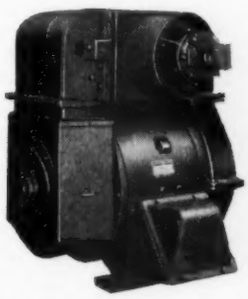
—for your d-c control needs

Convenient conversion of control power from a-c to d-c calls for a General Electric metallic rectifier. Whatever your particular need, meet it with a high-voltage selenium, low-voltage selenium, or copper-oxide type from the complete G-E line. Where high efficiency, uniformity and space economy are all-important, use the new high-voltage selenium rectifier cell shown. See Bulletin GEA-5280.

Dust and dirt can't stop them!

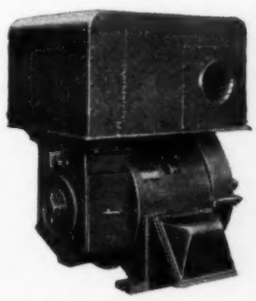
UNIT-COOLED D-C MOTORS

On large machine tools in dusty, dirty or oil-laden atmospheres—that's the place for General Electric totally enclosed, unit-cooled d-c motors. Completely factory-assembled, they save installation time and extra equipment cost. No need for specially built motor room, piping, ductwork, coolant, external filters, or pressurized air supply. Ratings from 15 to 200 hp. See Bulletin GEA-4469.



Single-blower type

For constant-speed or normal adjustable-speed operation—has shaft-driven fan to circulate internal air, and separate motor-driven blower for external air.



Double-blower type

For continuous operation at speeds below normal—uses one auxiliary motor to drive blowers for both internal motor air and external cooling air.

General Electric Company, Section A668-86
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☑ for reference purposes
- ☒ in connection with immediate projects
  - ☐ GEA-1497 Terminal boards
  - ☐ GEA-4469 Unit-cooled d-c motors
  - ☐ GEA-5153 A-c motor starters
  - ☐ GEA-5280 High-voltage selenium rectifiers
  - ☐ GEC-692 Short-stroke solenoids

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS!
You'll find "everything electric" for machinery manufacturers in the General Electric section.

NAME_____

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CITY_____ STATE_____

stop coupling failures!

FIND OUT HOW *Koppers Engineers Eliminate Needless Downtime* IN YOUR PLANT!

These FAST'S COUPLING *Services save you money!*

UNSURPASSED ENGINEERING . . . Koppers engineers are acknowledged the best in the industry. Their practical knowledge, backed with 30 years' coupling experience, is at your service!

IMMEDIATE DELIVERY . . . All standard types and sizes are available for immediate delivery from "on hand" stocks. In case of emergency, just wire factory for special rush delivery!

LOWEST COST PER YEAR . . . Fast's Couplings will outlast equipment they connect if properly maintained. Their cost may be spread out over 25 years or more, offering you lowest coupling cost per year!

Before your plant is harassed by needless coupling failures—*call on Koppers!* Only Koppers offers you a two barreled solution to coupling problems: Fast's Couplings, the original gear-type coupling—and Koppers Engineering Service, acknowledged the finest in the industry!

For *30 years,* Fast's Couplings have been industry's standard for *long life* at *low cost.* Now, in addition, when you specify Fast's you get the *extra* advantage of Koppers valuable Engineering Service. Koppers engineers, backed with 30 years of Fast's Coupling experience, study your problem. Then show *which* Fast's Coupling you need (and more important) *why you need it!*

Only Koppers can offer you both Fast's Couplings and unexcelled engineering service—so before you buy *any coupling,* get the complete story on Fast's. Full details are contained in the Fast's Catalog. For your free copy, send the coupon today!

KOPPERS

FAST'S

THE ORIGINAL GEAR-TYPE

Couplings

Send for

FREE CATALOG

KOPPERS CO., INC., *Fast's Coupling Dept.,*
342 Scott St., Baltimore 3, Md.

Please send me a copy of Fast's Catalog relative to.....
.....(type of industry).

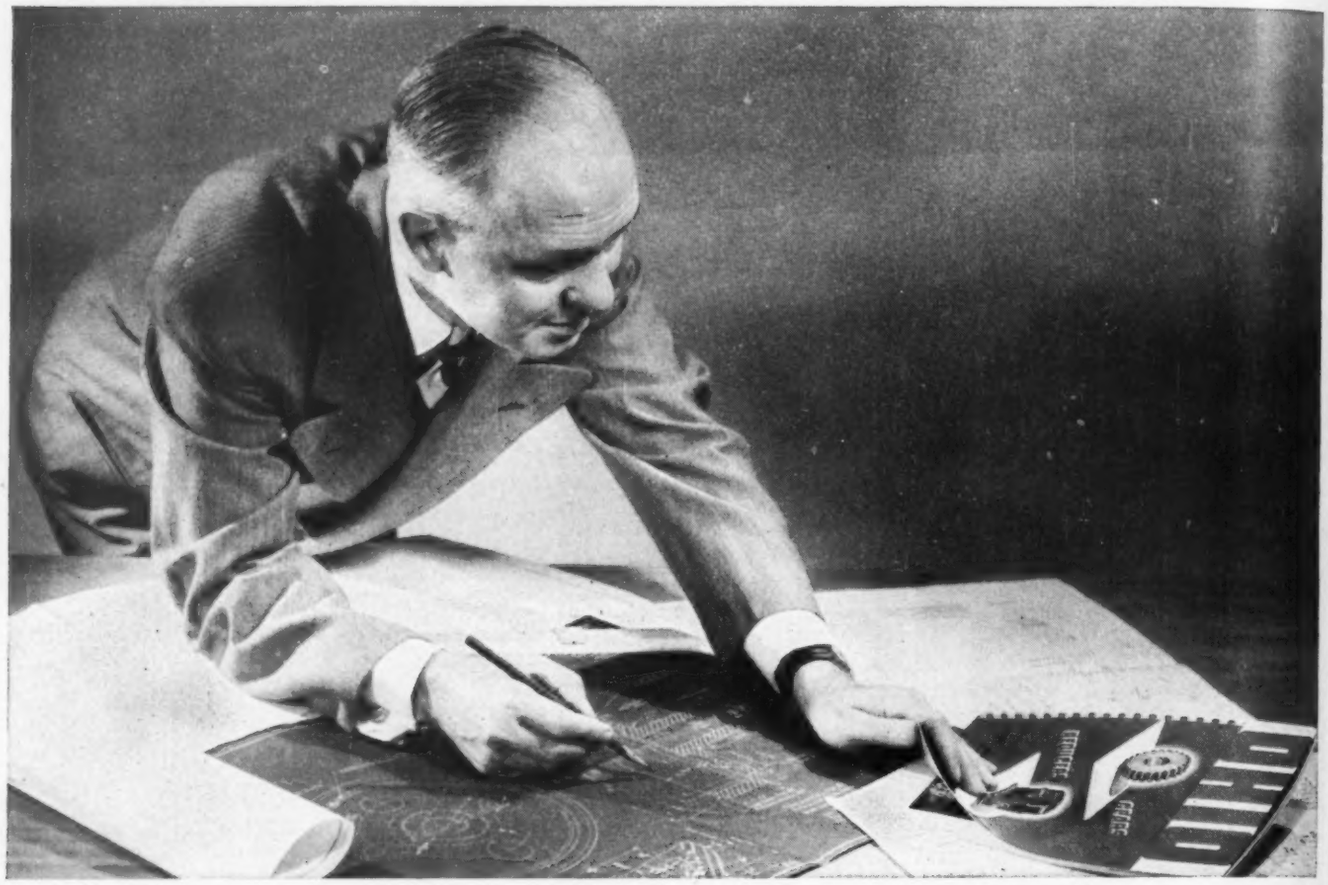
Name.....

Company.....

Address.....

City.....Zone.....State.....

HOW TO SAVE MONEY*



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*Akron, Ohio
Hardware & Supply Co.
*Baltimore, Md.
L. A. Benson Co., Inc.
*Brooklyn 6, N. Y.
(Gears) Northside Leather Belting Co., Inc.
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*Memphis 2, Tenn.
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U. and S., Inc.
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The Bearing & Transmission Co.

IN CANADA, *Montreal, Quebec, John Braidwood & Sons, Ltd.
*Stocks Carried.

ESTABLISHED 1915

THE OHIO GEAR COMPANY

1338 EAST 179TH STREET • CLEVELAND 10, OHIO

. . . ON YOUR PRODUCTION COSTS

If the machines or equipment you manufacture require gearing, speed reducers or motorized reducers, you can save substantially by standardizing on Ohio Stock Gears and Speed Reducers. They are precision made in every detail and fit perfectly into most applications. Produced in quantity runs they cost less and save the delivery time ordinarily required for "specials."

. . . ON YOUR MAINTENANCE COSTS

With Ohio Stock Gears and Reducers on your production machines you are sure of long, steady performance. However, when replacement becomes necessary, they cost less and you eliminate expensive down time waiting for deliveries.

*STANDARDIZE ON OHIO STOCK GEARS AND SPEED REDUCERS

Ohio Stock Gears and Speed Reducers are ordinarily available from your nearest distributors stock.

OHIO GEARS

ROSS SPRINKLER MAKES AN ANNOUNCEMENT:

"We say -- without hesitation -- that the brass Anaconda supplies for these sprinkler heads gives us the best drawing performance and the lowest reject rate of any brass we've ever used".

This was no accident. The customer's equipment, together with the number and extent of draws, were carefully considered. Then a brass alloy of suitable composition and temper was supplied. Results were evident immediately.

How about those deep-draw jobs of yours? Any room for improvement? Want the benefit of our experience – without obligation? . . . Just write to The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: New Toronto, Ontario. BC109

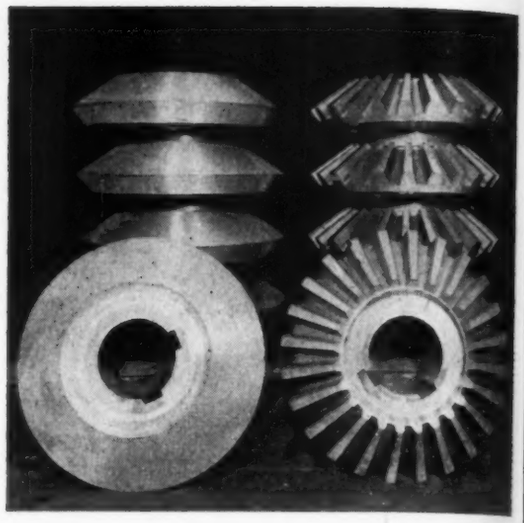
The Ross Sprinkler Company of Pasadena, California, in business since 1904, manufactures a broad line of Lawn Sprinkling Equipment and Air Conditioning Nozzles. Topmost illustration is full size; others indicate the extent of deep drawing required in producing the Ross No. 10 Solid Brass Hand Sprinkler.

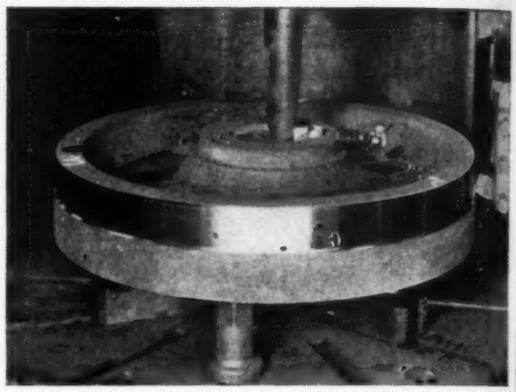
for better drawing brass

SPECIFY ANACONDA®

first in copper, brass and bronze

MAY WE SPEAK OUR PIECE ABOUT Gear Blanks?





These Bethlehem gear blanks are handsome to look at, and as good as they look. They're really something extra-special.

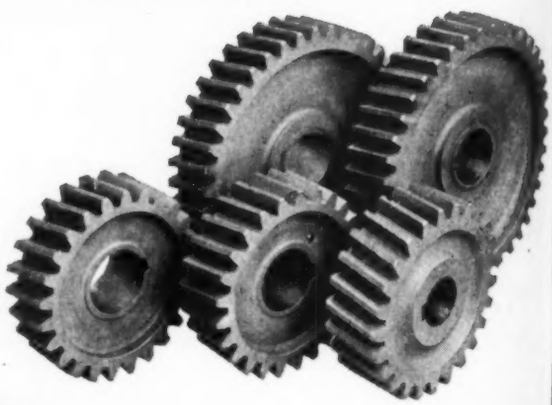
They're different from gear blanks made by conventional methods. In describing how they're made, we say that they're rolled and forged, or roll-forged. That is, the mill takes the hot blocks of steel, upsets them, and immediately rolls and forges in a single operation. Not just rolling, not just forging, but both . . . with the attendant *benefits* of both. Homogeneity, good grain structure, uniform density of metal.

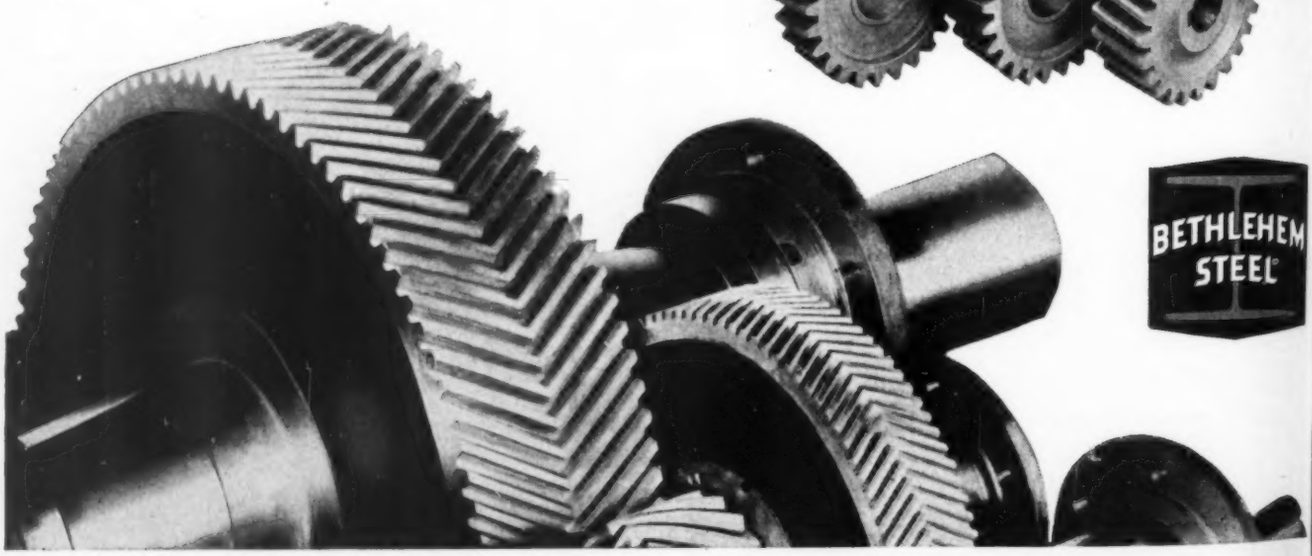
The blanks are also rough-machined (something you don't have to worry about yourself!); then they're shipped to you ready for finish-machining. Sizes, approximately 10 in. to 42 in. OD; orders heat-treated or untreated, as you specify.

You'll like these blanks—their strength, their fine surface, their all-around goodness. Be sure you get them when planning your next output of spur, herringbone, bevel, or miter gears. And write for Booklet 216—it tells about gear blanks and the many other uses of Bethlehem circular steel forgings.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation





BETHLEHEM STEEL

BETHLEHEM ROLLED-AND-FORGED CIRCULAR PRODUCTS

MOTOR PARTS by R & M

For portable tools and *everything else* that needs compact, built-in power, Robbins & Myers Matched Motor Parts are adaptable—*always* dependable. They simplify modern styling; cut equipment assembly time. And, since R & M parts for all the different motor types are interchangeable, users get *utmost benefits* from product standardization.

PERFORMANCE TELLS THE STORY

As a *leading* motor-parts maker—with over forty years of service to the nation's volume users—Robbins & Myers has demonstrated time and again that broad experience, progressive ideas, and *willing cooperation* can meet exacting powering needs, whatever the requirements. In standardized elements, or parts built-to-order, the R & M concept and R & M skills save users time, trouble, and money.

INVESTIGATE THESE EXTRA VALUES

Millions of units for the plant, home, and office are "*Powered by Robbins & Myers*" because R & M Motors and Matched Motor Parts are so reliable and right. Find out what this can mean to you in satisfaction, savings. Sizes 1/200 to 50 h. p.

Robbins & Myers is big enough to serve your every need completely, yet not too big to serve you personally and promptly. For literature or gratis aid in solving powering problems, address Dept. E-120

●

MOTOR DIVISION

ROBBINS & MYERS INC.

SPRINGFIELD 99, OHIO
BRANTFORD, ONTARIO

MOTORS • HOISTS • CRANES • FANS • MOYNO PUMPS • FOUNDED 1878

DESIGN LEADERSHIP *Pays*

SQUARE D MACHINE TOOL RELAYS

Design Features

Small Size without sacrifice of accessibility or rating.

Accessible Terminals accommodate multiple connections.

Hardened Parts for long mechanical life. Magnet frame, armature, and other steel parts with bearing surfaces, are hardened.

Double-Break Silver Contacts, convertible from normally open to normally closed without additional parts, for maximum flexibility.

Two to Eight Poles in any combination of normally open and normally closed contacts.

Steel Panel Mounting and front connections.

Non-Carbon Tracking melamine yoke bar, together with porcelain contact block, for high arc resistance and dielectric strength.

Write for Machine Tool Relay Bulletin 8502 BHO.
Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin.

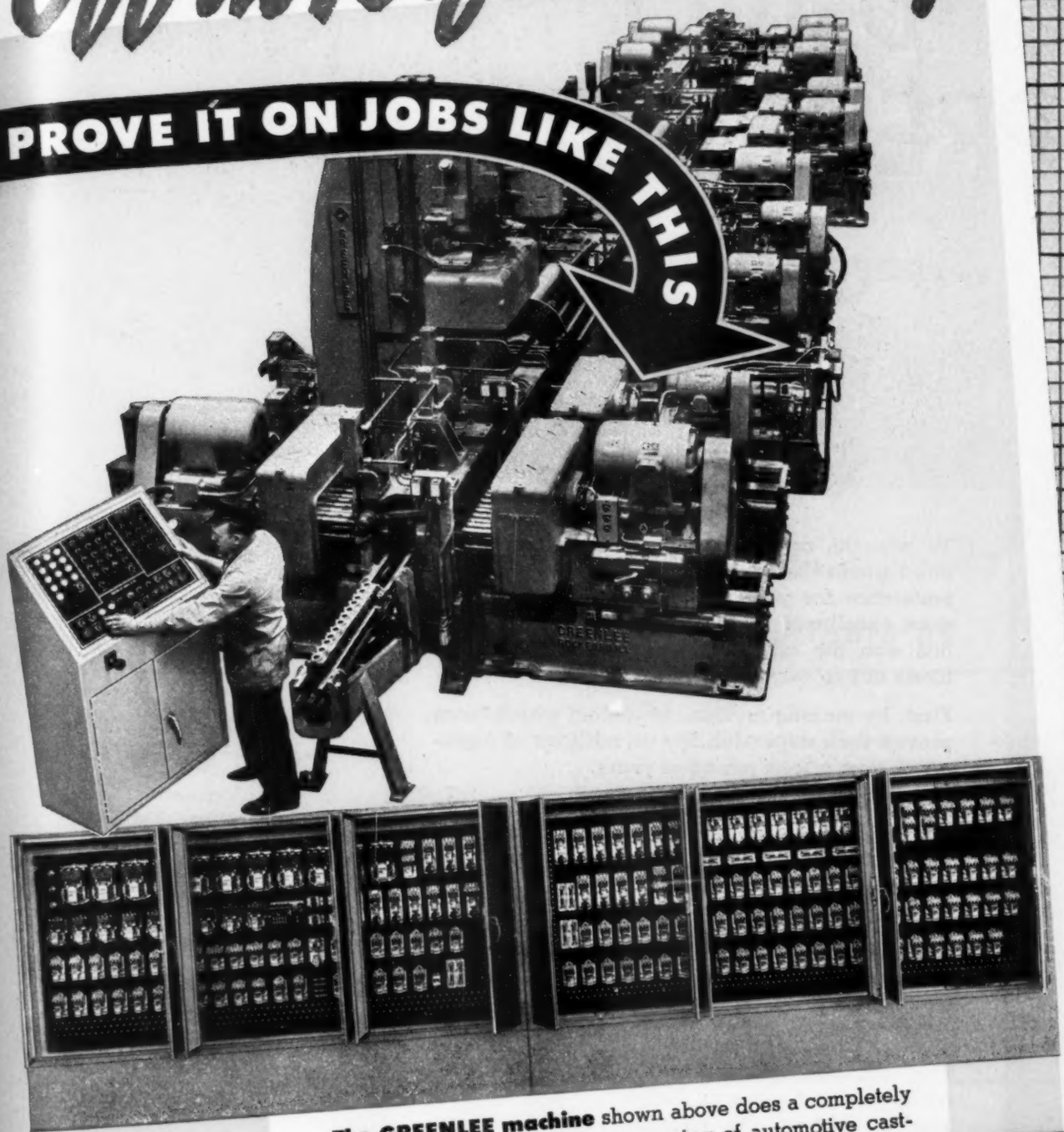
SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

Off in Performance!

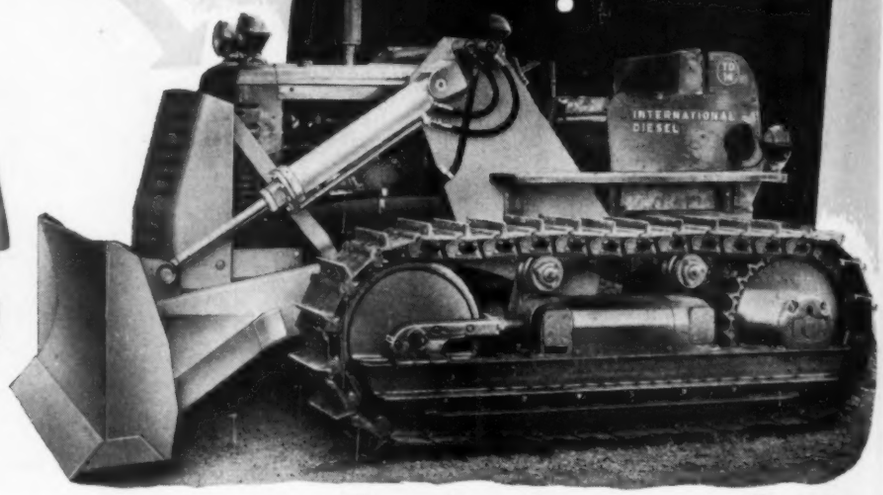
PROVE IT ON JOBS LIKE THIS

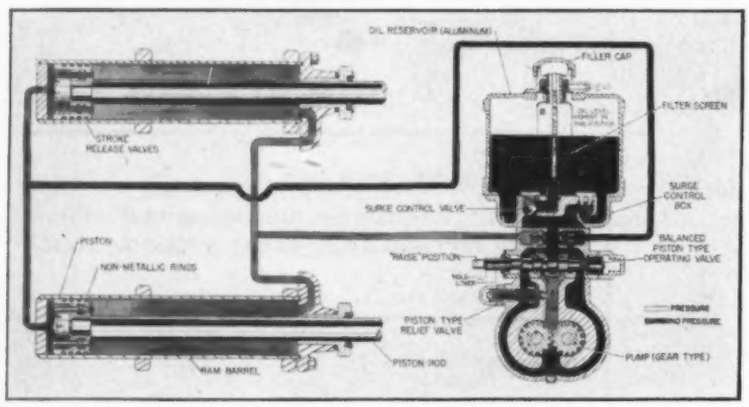


The GREENLEE machine shown above does a completely automatic job...straight line processing of automotive castings. "Down" time in mass production operations like this one can be a very costly factor. Square D's machine tool relays pay off because they're designed for consistent performance, long life, easy inspection and maintenance. They definitely minimize "down" time.

Good Equipment Made Still Better with LaPLANT-CHOATE HYDRAULIC UNITS

SPEED • POWER
VERSATILITY • SIMPLICITY
TROUBLE-FREE OPERATION





Top Performance Built into Bros Dozers with LPC Hydraulic Units

FOR their *Power-Plus* Bulldozer, Bros engineers wanted speed and power for fast work under heavy loads . . . instant response to controls . . . simple, compact design . . . trouble-free operation. A complete LaPlant-Choate Hydraulic System consisting of jacks and the famous "packaged" hydraulic fluid power unit, was chosen to meet all requirements . . . to make their *good* product still *better.*

Design Your Product for Better Performance

Whatever your problem, you'll get more efficient operation, simpler design and greater sales advantages for your product when you use LaPlant-Choate Hydraulic Units as standard equipment. Here are some of the features that will make your product better — *Compact Design* with pump, control valve, relief valve and reservoir contained in one simplified unit; *Versatile Application* on any type of machinery or equipment; *Multiple Use* of one installation with multiple valves, combinations and oil circuit variations; *Positive Fingertip Control* results in a high degree of operating accuracy and precision; *Easily Installed* and adaptable to a wide choice of mountings; *Low Maintenance* and *Long Life* under the most adverse operating conditions.

Write for complete information about making your products easier to design, manufacture, sell and service. Ask for Bulletin B-1152B LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa.

THE LaPLANT-CHOATE FAMOUS FLUID POWER CONTROL

Pump, valve and oil reservoir are all combined into a single compact unit that mounts on the front of the tractor behind the radiator guard. This new "closed system" design completely eliminates long suction lines, reduces the hazard of leaks and assures greatly increased speed and efficiency. In addition, the entire unit is skillfully engineered and precision built for utmost simplicity, easy servicing, and long, trouble-free operation.

LaPLANT CHOATE

Star Performers

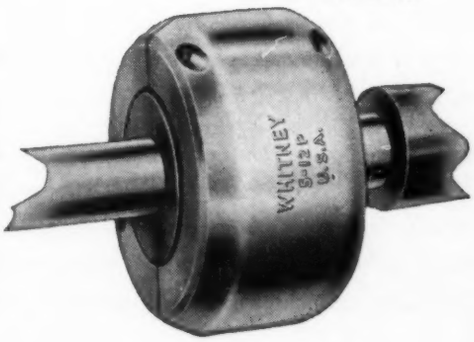
in Simplifying Drive Designs and Reducing Power Transmission Costs

WHITNEY CHAIN DRIVES

Whitney Roller Chains in single or multiple widths.

Whitney Cut Tooth Sprockets for all types of chain.

Whitney Roller Chain Flexible Couplings for positive yet flexible direct drives.



Whitney Silent chains for quiet, high speed power transmission.

Cost and performance records across all types of industry . . . on all sorts of equipment . . . prove that versatile Whitney Chain Drives not only simplify your drive selection, but reduce costs as well.

For example — these quality drives will operate on long or short centers, drive shafts clockwise or counter clockwise . . . singly or simultaneously. And from the cost angle, remember that Whitney Chain Drives deliver *full rated* machine output without friction loss or slippage. Their alloy steel construction, to Whitneys' renowned quality standards, assure long service life with minimum maintenance.

PLUS WHITNEY SERVICE — And Remember — Whitney Chain Drives . . . roller, silent, conveying chains, and cut-tooth sprockets . . . are carried in stock by a nation-wide network of more than 130 Whitney distributors. This fast local service saves you time, assures prompt delivery of your chain drive requirements. In addition, 15 Whitney field offices, strategically located throughout the country, are at your service to help you solve your power transmission problems. For Catalog or specialized Whitney field offices write:

WHITNEY CHAIN COMPANY

205 HAMILTON ST., HARTFORD 2, CONNECTICUT

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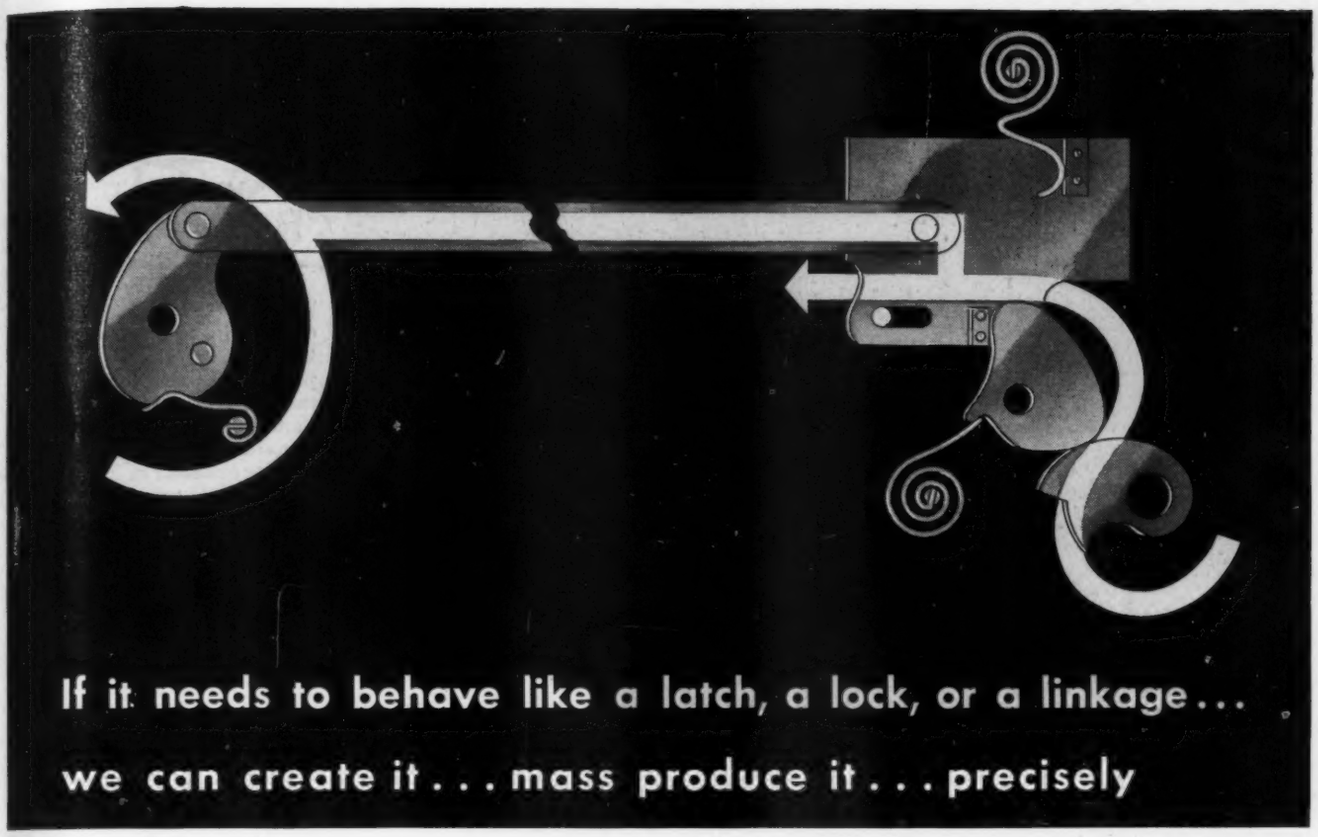

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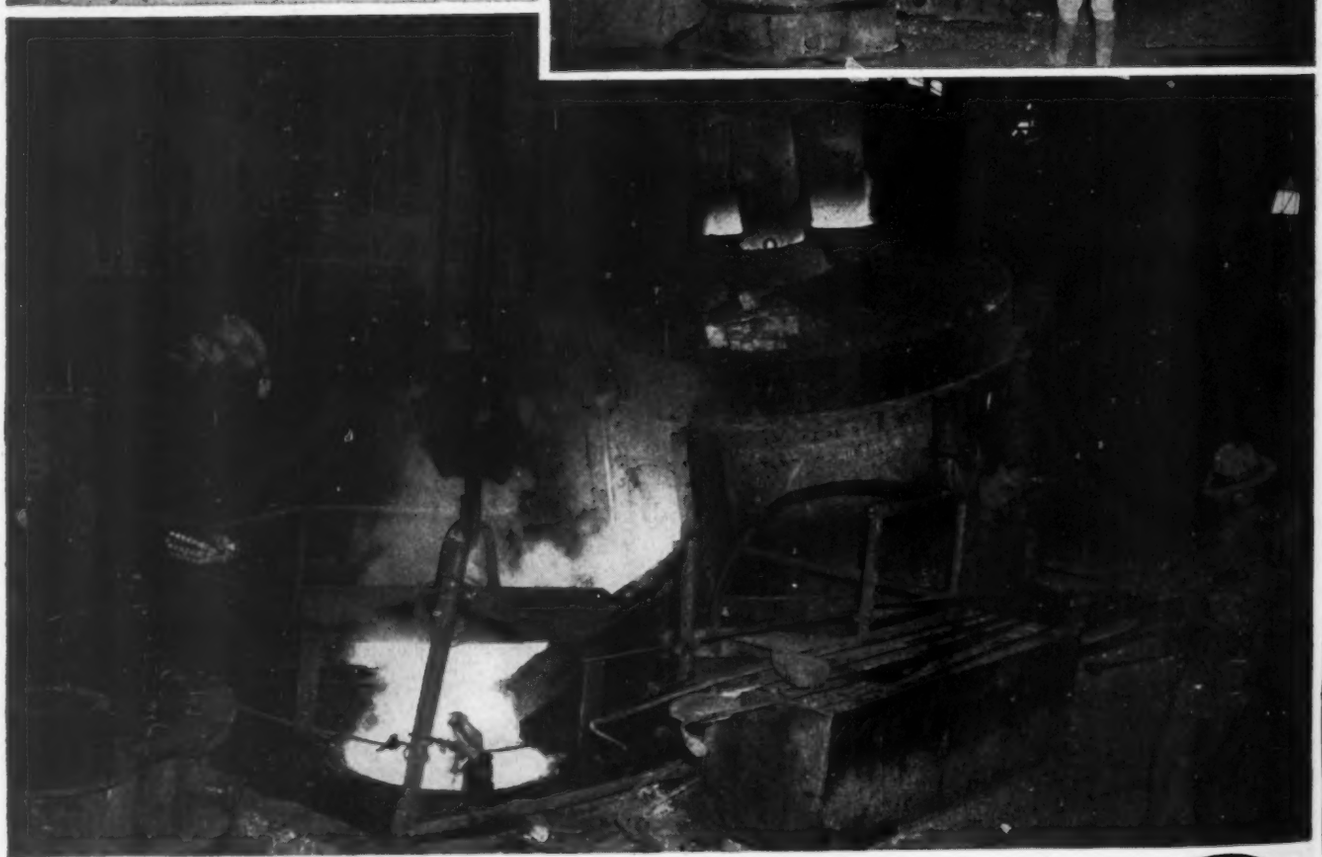

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PUROLATOR ENGINEERS

Choose P PERMITE

ALUMINUM CASTINGS

The body for a good oil filter should be seamless, light-weight, non-corrosive, attractive in appearance — and contribute to manufacturing economy. How these requirements were met by Permite Aluminum Castings (produced by the permanent mold process) for the Purolator Oil Filter shown here, is told by Purolator Products, Inc., Rahway, N. J., a leading manufacturer of oil filters for the automotive industry.

Letter from Purolator says:

"Here are a few reasons why our design engineers prefer Permite castings:

1. **The material can be cast in one piece, which makes for accuracy and low cost.**
2. **Machinability of Permite is excellent.**
3. **Permite aluminum castings do not need special finishing because they have their own bright, colorful, shiny finish.**
4. **Aluminum is non-corrosive, does not oxidize, therefore does not need protection.**
5. **A Permite aluminum casting is light in weight, yet has excellent strength factors and can easily withstand the stress placed upon it, in its use, attached to the engine of an automobile."**

This Purolator Oil Filter — with Permite cast aluminum body — is a special full flow type used as original equipment on one of America's finest automobiles.

Have *you* thought about using Permite castings in your products? It's possible that light-weight, precision-made Permite Aluminum Castings could save you thousands of dollars a year in handling costs, machining costs, finishing costs, shipping costs. Send us your blueprints and castings requirements for free quotations and recommendations.

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The public is benefitted with faster, safer, more comfortable and modern travel accommodations; the roads benefit because stainless steel saves on expenses and increases profits. Today you'll find Allegheny Metal used not only for entire trains, but in dining-car kitchens, sleeping-car equipment, refrigerator cars, and tank cars for the transportation of milk, chemicals, etc.

Rail equipment is only one of the vital uses for stainless steel in general industry and the national defense. In the past decade, we have spent many millions to increase the supply of Allegheny Metal and other alloy products, and are in the process of spending millions more. ● In the national interest, let us help you to use stainless steel most efficiently, and make the available supply go farther.

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Complete technical and fabricating data—engineering help, too—are yours for the asking from Allegheny Ludlum Steel Corporation, Pittsburgh, Pa. . . . the nation's leading producer of stainless steel in all forms. Branch Offices are located in principal cities, coast to coast, and Warehouse Stocks of Allegheny Stainless Steel are carried by all Joseph T. Ryerson & Son, Inc. plants.

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You can make it **BETTER** with

Allegheny Metal

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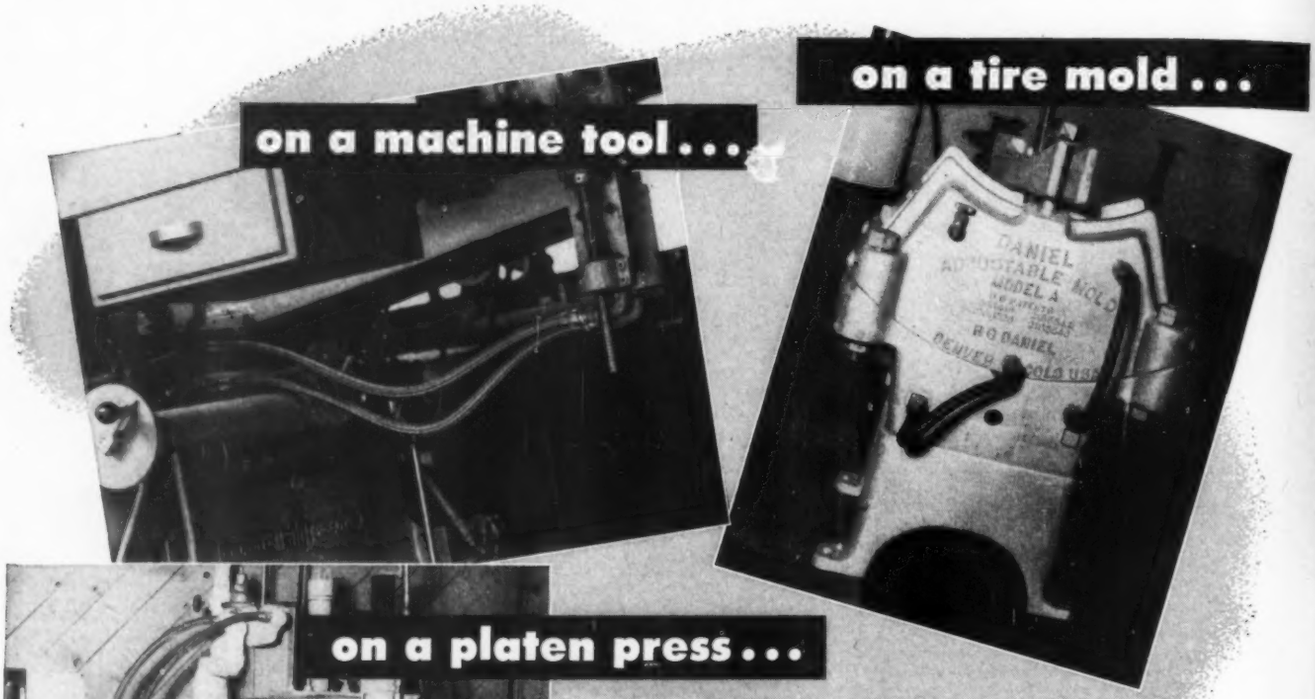
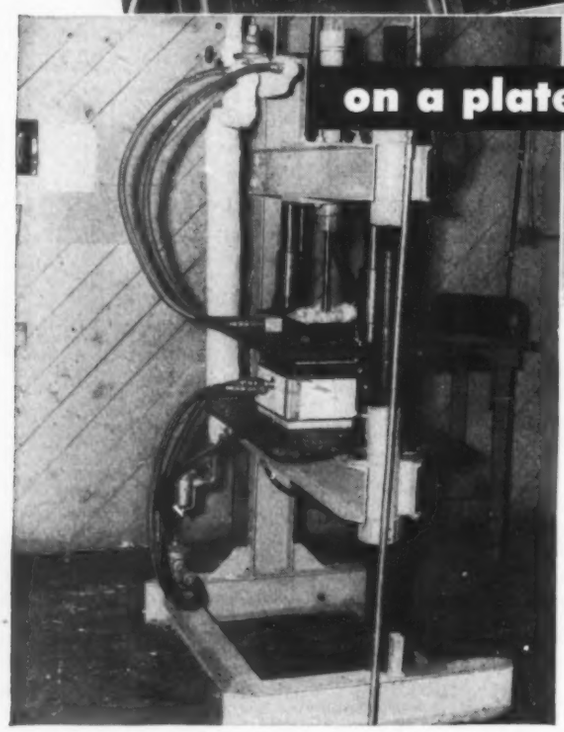
TIME-TESTED STAINLESS STEEL

Where Connections Must Move . . .





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FLEXIBLE METAL HOSE solves the problem economically and dependably

Whatever the product you are designing—if connections must be made between relatively movable parts to convey high or low temperature liquids or gases under pressure or vacuum, CMH Flexible Metal Hose is the answer. CMH corrugated flexible metal hose will withstand frequent and repeated flexing . . . has high resistance to external damage. REX-WELD steel and bronze hose is available in standard sizes from 3/16" through 12" I.D. for burst pressures to 12,000 psi, temperatures to 1000° F. REX-FLEX stainless steel hose is manufactured in sizes from 5/16" through 6" I.D. for working pressures to 2000 psi, temperatures to 1400° F. Both types are available with or without metal braid covering.

Literature and data sheets are available for CMH REX-WELD and REX-FLEX corrugated flexible metal hose. Write, today, briefly outlining the nature of your flexible connection problem and we will be pleased to send you the appropriate descriptive material.

Flexon identifies CMH products that have served industry for over 48 years.

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MEMO

To: users of A.C. adjustable Speed Drives

From: THE LOUIS ALLIS CO.

Only SELECT-A-SPEDE

offers the NEW MAGNETIC AMPLIFIER CONTROL with superior performance at no extra cost!

Easy to install and operate • Simple circuits, easy to maintain • Compact design saves floor space

THE MAGNETIC AMPLIFIER

– HEART OF THE SELECT-A-SPEDE

The Magnetic Amplifier, a self-saturating reactor, like a transformer, contains no moving parts — no parts requiring maintenance or periodic replacement. Its function in the Select-A-Spede, is to constantly regulate the field currents of both motor and generator. It requires no "warm up" period, has an extremely fast response to changing conditions, and is completely reliable at all times.

For economical "on the spot" conversion of AC power for an adjustable speed drive (even better than a DC motor supplied from a constant voltage power supply) — the Louis Allis Select-A-Spede is unsurpassed. It is the only AC adjustable speed drive offering the advantage of the new magnetic amplifier control — with close speed regulation at all rated speeds and loads.

The Select-A-Spede also offers a variety of optional features, such as: reversing, dynamic braking, jogging, sequence control, controlled acceleration, interlocked slow speed start, multi-motor drives, etc. It is possible to provide a Select-A-Spede Drive to exactly suit your special requirements.

For further information, contact your nearest Louis Allis Application Engineer or write for Bulletin 1100-B.

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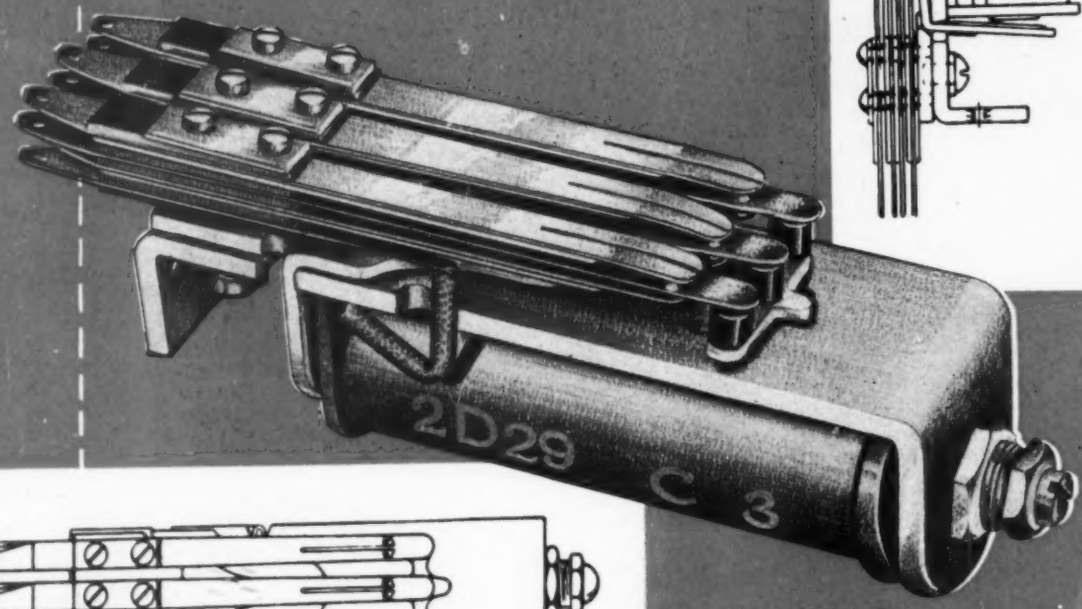
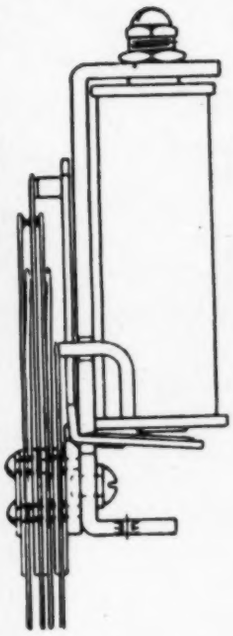
THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.

NORTH RELAYS

simple · sturdy





reliable · efficient

BECAUSE their basic principle is so simple, it's easy to believe that anyone can make relays: But, where dependability, reliability and efficiency are specified, such belief leads to certain disappointment.

If you are designing circuits requiring absolute quality, with zero failure, you must have relays backed by years of experience and a very special know-how. North Relays have just such backing. We've been in the business since 1884, engineering and producing millions of relays, from multiples to midgets, from simple single-makes to intricate pileups with any combination of makes and breaks.

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—— Originators of ALL RELAY *Systems of Automatic Switching ——*

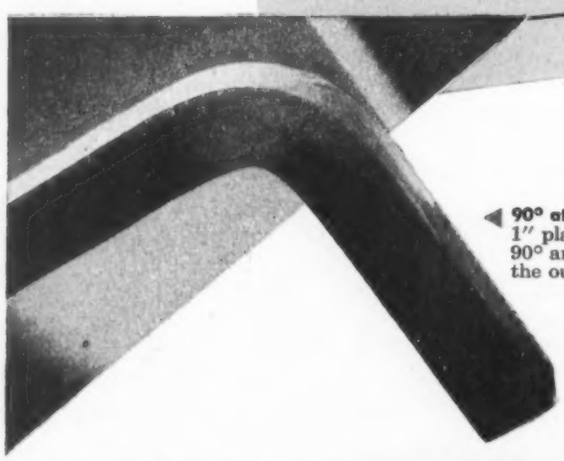
Announcing... U·S·S

A NEW HEAT-TREATED ALLOY STEEL WITH

MECHANICAL PROPERTIES—U·S·S Carilloy T-1 Steel can be furnished Heat Treated to the following mechanical properties:

	Thickness ¼" to 2" incl.	Thickness Over 2" to 4" incl.	Thickness Over 4" to 6" incl.
Yield Strength, 2% Offset (min.)	100,000 psi	90,000 psi	90,000 psi
Tensile Strength (min.)	115,000 psi	105,000 psi	105,000 psi
Elongation in 2", % (min.)	18	17	16
Reduction of Area, % (min.)	55	50	45
	Thickness ¼" to ½" incl.	**Thickness Over ½" to 1" incl.**	**Thickness Over 1" to 2" incl.**
Cold Bend	180°D=1t	180°D=2t	180°D=3t

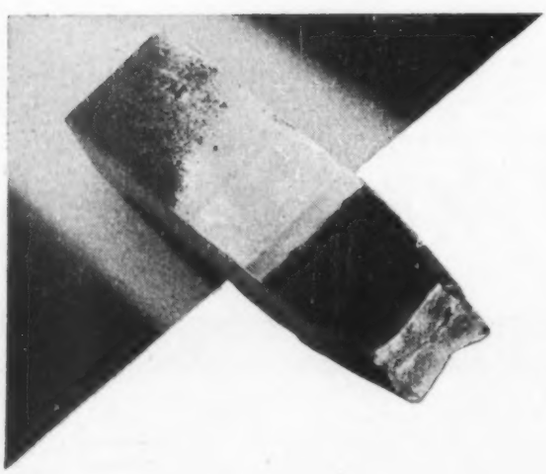
(Testing in accord with A.S.T.M. recommended practices.)

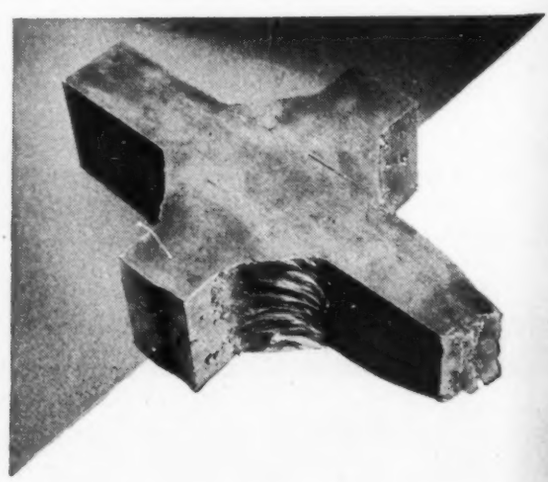


Look at these test results:

◀ **90° at 98 below!** The sample here was flame-cut from 1" plate. Then it was chilled to -98°F, and bent to a full 90° angle. Even though the raw, flame-cut edge made up the outer radius of the bend, there was no sign of failure!

▼ **100% WELD STRENGTH**—Tensile tests on welded specimens like these prove that welds on CARILLOY T-STEEL are 100% efficient. Welds develop the *full* strength of the parent metal. Note that breaks occur outside the heat-affected zone. No special pre-heating or post-heating treatments are required beyond those used with ordinary structural steels.





Carilloy T-steel

THIS REMARKABLE COMBINATION OF PROPERTIES

1. High yield strength of 100,000 psi minimum.

2. Strong and ductile even at 100 below zero!

3. Readily weldable - - without loss of strength or ductility.

HERE is a new alloy steel developed especially for heavy-duty equipment that must withstand a lot of abuse in all sorts of climates — in the scorching heat of summer and the bitter cold of winter — yet with all this, it's a steel that can be easily gas-cut and readily welded.

U·S·S CARILLOY T-STEEL was developed by Carnegie-Illinois research. It provides a unique combination of superior strength and unusual ductility. This low carbon *alloy* steel can actually be welded and gas-cut as readily as structural *carbon* steel.

Plates of CARILLOY T-STEEL from ¼" up to 2" in thickness have a minimum yield strength of 100,000 psi even *after* welding and gas-cutting. Despite this very high strength, T-Steel will remain tough and ductile at any climatic temperature. That's why CARILLOY T-STEEL is made to order for heavy-duty equipment that must operate out-in-the-open under high impact loads and without danger of failure.

The *full* strength of CARILLOY T-STEEL can be utilized in designing welded construction because the high physical properties are not affected by welding or gas-cutting.

U·S·S CARILLOY T-STEEL has been developed for use in the form of plates and bars. Its nominal hardness is 250 Brinell. For abrasive conditions, where high hardness *and* toughness and weldability are essential, hardness up to 320 Brinell minimum can be furnished.

SEND THE COUPON

Carnegie-Illinois Steel Corporation
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Pittsburgh 30, Pa.

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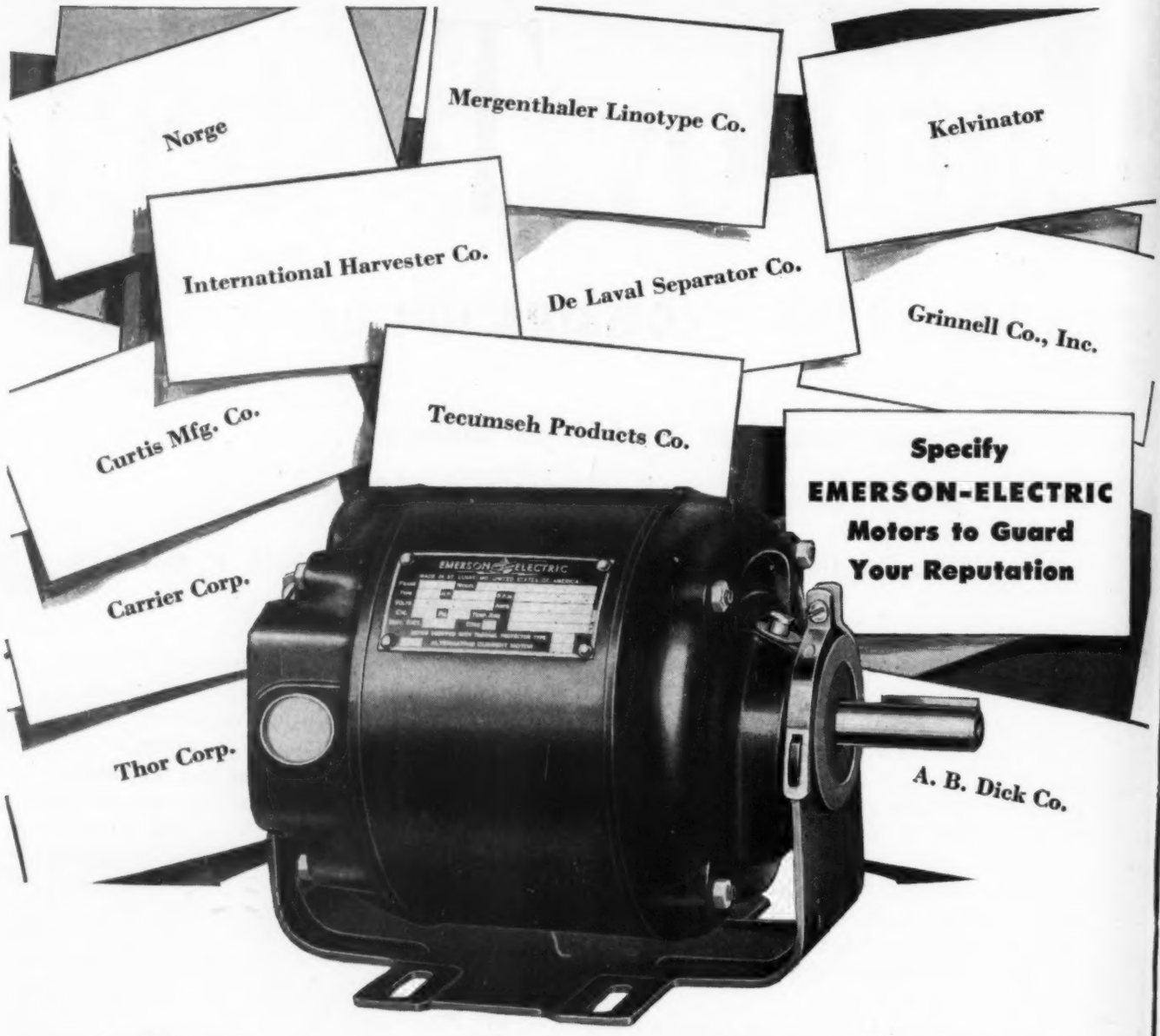
UNITED STATES STEEL



Called upon...by American Industry

Write for these Emerson-Electric Motor Data Bulletins

Appliance and equipment manufacturers, with applications for motors of 1/20 to 5 h.p., can profitably use these authoritative reference guides. Specifications, construction details and performance data are included for the following types:

- ☐ No. 390-A Capacitor-Start Motors
- ☐ No. 390-B Split-Phase Motors
- ☐ No. 390-C Integral Motors
- ☐ No. 390-D Fan-Duty Motors
- ☐ No. 390-E Oil-Burner Motors
- ☐ No. 390-F Jet Pump Motors
- ☐ No. 390-G Blower Motors

Take a look at these famous names in American industry. They represent but a few of the scores of manufacturers who depend on Emerson-Electric to power their products . . . companies who stake their reputations on the *performance* of Emerson-Electric Motors.

Naturally, we are proud that Emerson-Electric's record of *proved* motor performance has earned the right to be associated with these names.

You may find that adding your name to those above will be the ideal answer to your motor requirements. Emerson-Electric offers you a complete line of motors in the 1/20 to 5 h.p. range . . . motors whose reputation rests on unvarying efficiency and dependability.

We welcome your inquiry. Call on, depend on Emerson-Electric for motors designed to fit your needs.

THE EMERSON ELECTRIC MFG. CO.

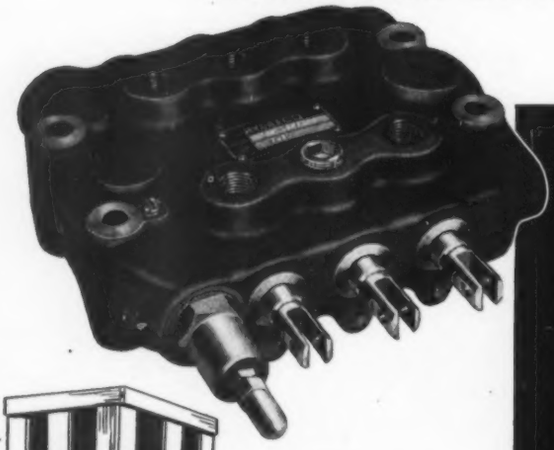
ST. LOUIS 21, MO.

EMERSON ELECTRIC

MOTORS • FANS — APPLIANCES

DO YOU USE Oil Hydraulics?

80% of all leading industrial lift truck manufacturers use...

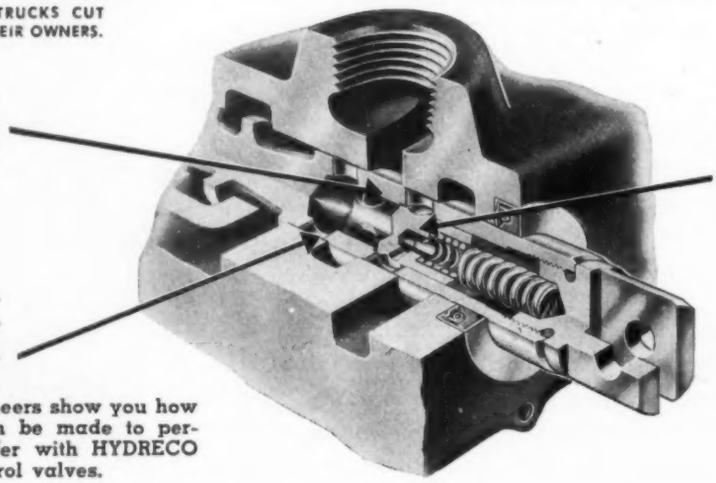


HYDRECO
HOLLOW-PLUNGER* VALVES

— for smooth and accurate control of raising, tilting and accessory operations.

HYDRECO Hollow-Plunger control valves build in the fast and safe control so necessary to proper lift truck operation. Accurate throttling characteristics, inherent in HYDRECO valves, cut out lost motion in picking up and stacking. Built-in check valves of the Hollow-Plunger design entirely eliminate momentary load drops and jerky operations. There are no dead spots in HYDRECO valve operation to create pressure peaks, damaging to the hydraulic system.

HYDRECO EQUIPPED TRUCKS CUT OPERATING COSTS FOR THEIR OWNERS.



Patented hollow plunger with no dead spots to create pressure peaks.

Check valve assembly prevents pressure drop in the cylinder while pressure port is opening.

Circular ports are staggered in the plunger for accurate throttling.

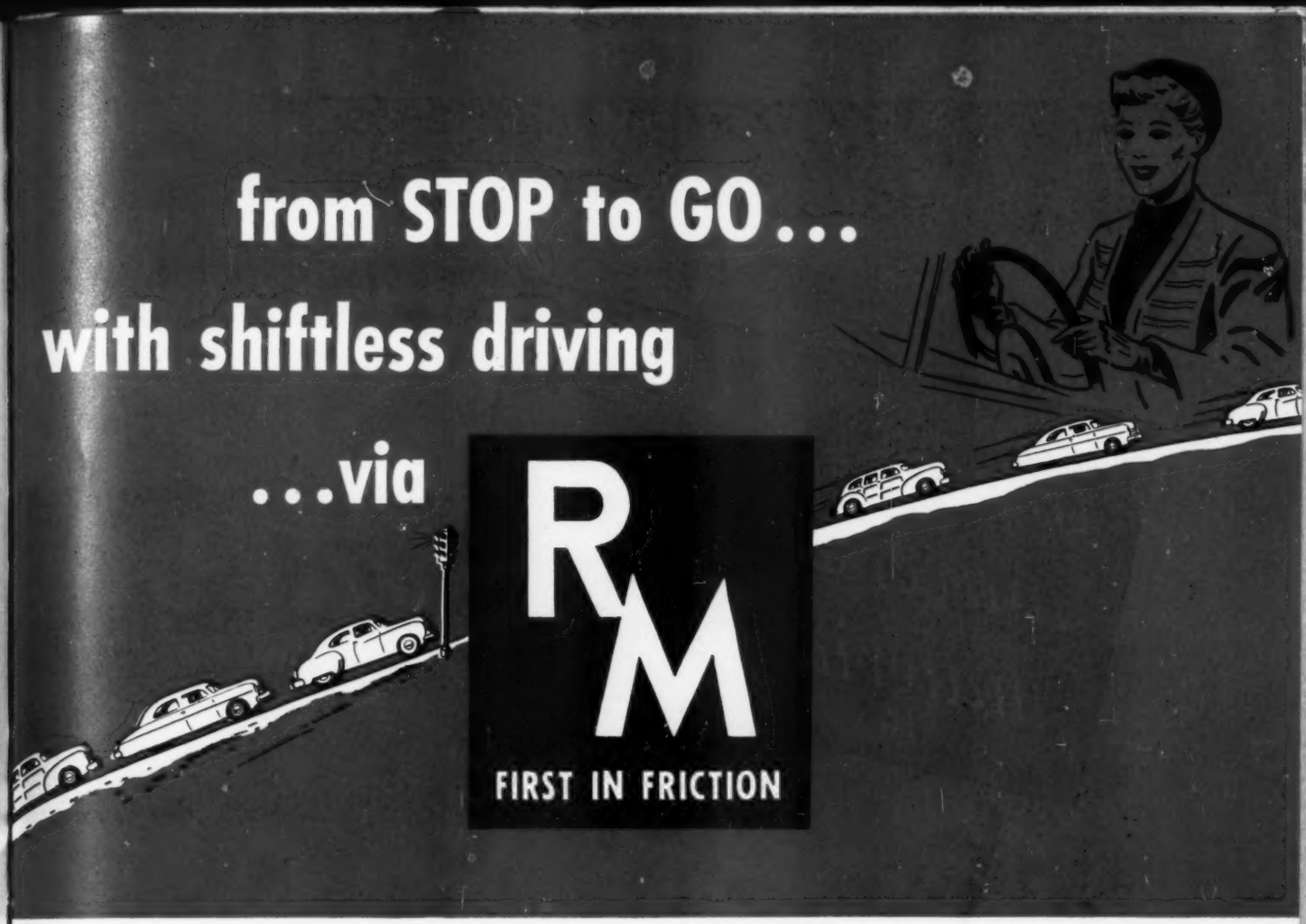
*Hollow-Plunger protected by existing U. S. and Foreign Patents as well as patents applied for.

Let HYDRECO engineers show you how your equipment can be made to perform faster and safer with HYDRECO Hollow-Plunger control valves.

WRITE TO —

HYDRECO
HYDRAULIC CONTROL DEVICES
PUMPS · CYLINDERS · VALVES

HYDRAULIC EQUIPMENT COMPANY
1106 EAST 222nd STREET • CLEVELAND 17, OHIO



More and more American motorists call for automatic transmission . . . and the industry meets the demand! Production of automatic units keeps going up . . . up . . . up. R/M plays an interesting part. *Every* automatic transmission now in production employs friction material made by R/M, the largest producer in the field. Some of these materials are woven, some molded; some are compounded, in whole or in part, of powdered metal; many are bonded to metal backings. Other R/M products are used constantly for clutches and brakes covering an even wider range. The experience thus gained is available to all manufacturers faced with problems in metallic and asbestos friction materials, as well as in rubber products. Your R/M representative is the man to see!

RAYBESTOS-MANHATTAN, INC.

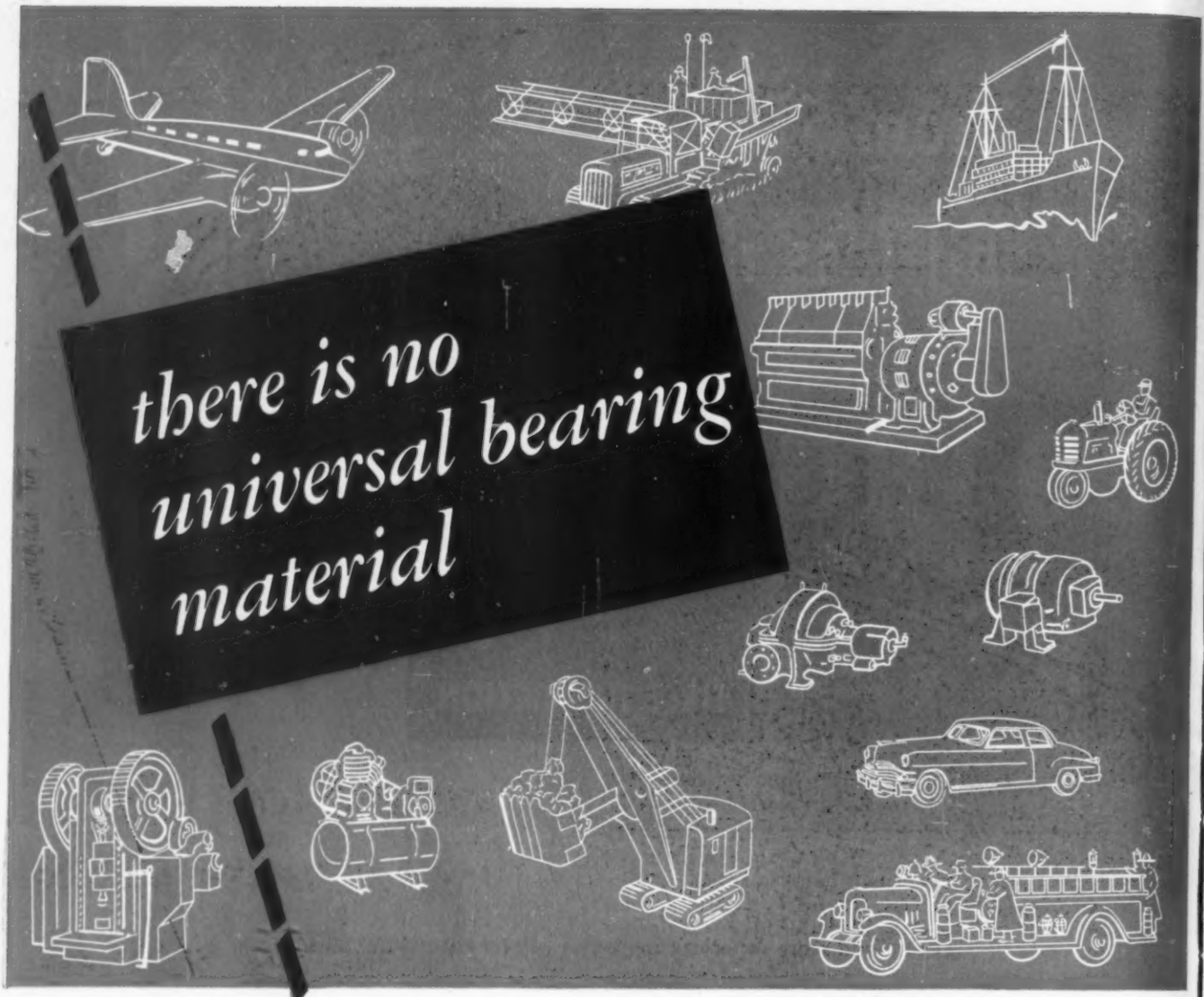
EQUIPMENT SALES DIVISION — **620 Fisher Bldg., Detroit 2, Mich.**

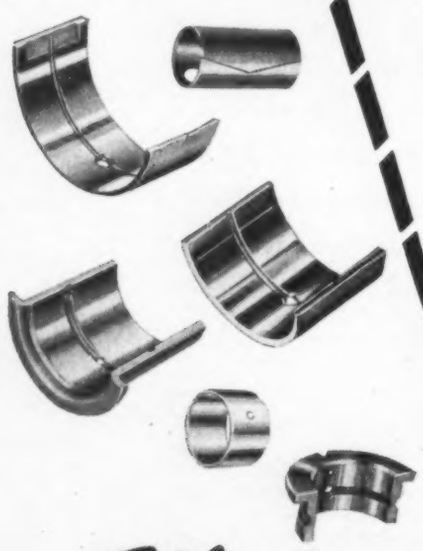
445 Lake Shore Drive, Chicago 11, Ill. — 4651 Pacific Blvd., Los Angeles 11, Calif.

1071 Union Commerce Bldg., Cleveland 14, Ohio

Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C.

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls





Silent
SLEEVE
BEARINGS

12 MACHINES

How many different Bearings?

There may be 20, 40 or more variations and combinations of alloys and designs in the sleeve bearings. One engine may require different bearing alloys for main bearings, connecting rod bearings, camshaft bearings, piston pin bushings and water pump bushings. That's one reason why, as long-time specialists in research, design and manufacture of sleeve bearings, we specialize in *variety*. Our seven manufacturing plants produce sleeve bearings and bushings in a wide range of material combinations and sizes, in quantities from dozens to millions.

Send for handy Bulletin for your reference file. It shows the "field of usefulness" for a wide range of bearing alloys, and provides a ready reference on bearing applications for your library.

FEDERAL-MOGUL CORPORATION, 11045 Shoemaker, Detroit 13, Michigan

FEDERAL-MOGUL

OVER FIFTY YEARS OF CONTINUOUS BEARING EXPERIENCE

SIMPLIFY YOUR DRIVE LAYOUTS WITH VEELOS

... and you can fit the belt to the machine ... not the machine to the belt

YOU know the advantages of complete freedom of design when it comes to power delivery. Often machine efficiency can be stepped up by placing the motor in the most desirable position—but, because of the limitations of endless v-belts, this is not always possible.

With Veelos, the adjustable v-belt, no such limitations exist. In addition, sliding and pivoted type motor bases are not needed. Idlers are not necessary for belt take-up on fixed center drives. Outboard bearings can be used where required and Veelos can be installed without dismantling any part of the machine.

Correct belt tension, important for full, smooth power transfer, is another plus factor found in Veelos.

Veelos is made in all standard widths: 00, 0, A, B, C, D and E. It is available in three types: regular, oil-proof and static conducting. Also Veelos double V in A and B widths.

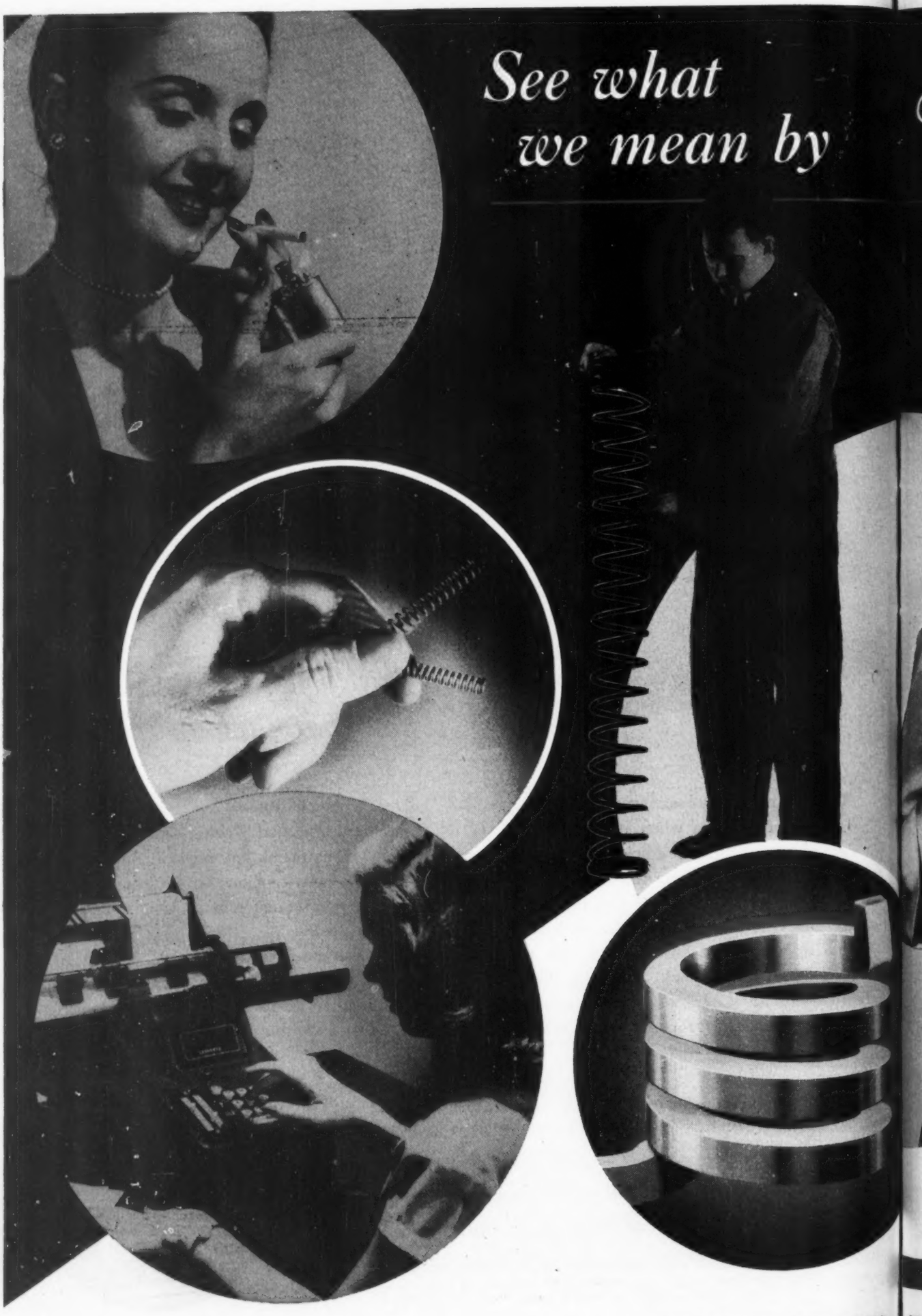
You are invited to consult our engineers on your particular v-belt needs and we believe you will find it advantageous to do so. If you do not have a copy of the Veelos Data Book let us send one on to you immediately.

MANHEIM MANUFACTURING & BELTING COMPANY • MANHEIM, PA.

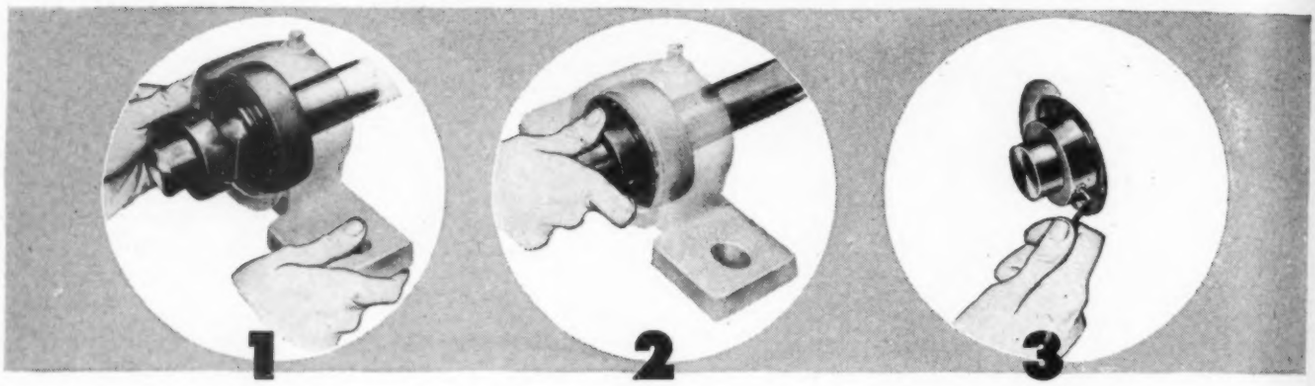
VEELOS
THE LINK
V-BELT

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities. Veelos is known as VEELINK outside the United States.


See what
we mean by

Some still say:
"It can't be that simple"



To those who have struggled with shaft shoulders, lock nuts, adapter sleeves and other gadgets for holding a bearing to a shaft it is understandable why some still say: "It can't be that simple", when they see how easy a Fafnir Wide Inner Ring Ball Bearing with the famous Self-Locking Collar slides on and fastens to a shaft.

If you believe that "seeing is believing" try Fafnir Ball Bearing Power Transmission Units on your next installation. We'll let you judge for yourself.

To make it simple for you, a nearby Fafnir Distributor will supply the units best suited for your requirements. The Fafnir Bearing Company, New Britain, Conn.

It's this simple

1
Slip it over the shaft.

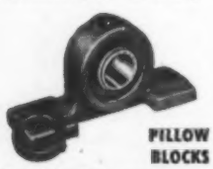
2
Engage and turn the collar.

3
Set the screw.

that's all

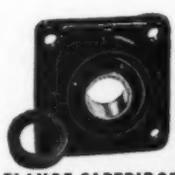
FAFNIR BALL BEARING POWER TRANSMISSION UNITS
Self-aligning. Sealed for long, uninterrupted service. A type and size for every condition.

PILLOW BLOCKS
Mechani-Seal Type. Two Series: Light and Heavy



PILLOW BLOCKS
With labyrinth seals, and single or double dirt guards. Two Series: Standard and Heavy

RUBBER MOUNTED UNITS
Pillow Blocks
Flange Cartridges



FLANGE CARTRIDGES
Mechani-Seal Type. Two Series: Light and Heavy

PILLOW BLOCKS Fixed and Floating Types. Two Series: Standard and Heavy

DOUBLE RIGID PILLOW BLOCKS Heavy Duty

FLANGETTE
With pressed steel flanges

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

skill to design . . . facilities to produce

SHAPES

and metal tubing

Designing and building tools and dies, as well as forming shapes and tubing in our own modern plant assures you of rigid control throughout the various phases of manufacture. This "under one roof" procedure, supervised by engineers whose knowledge of the uses which rolled shapes and tubing can serve, eliminates guesswork and delay in overall production.

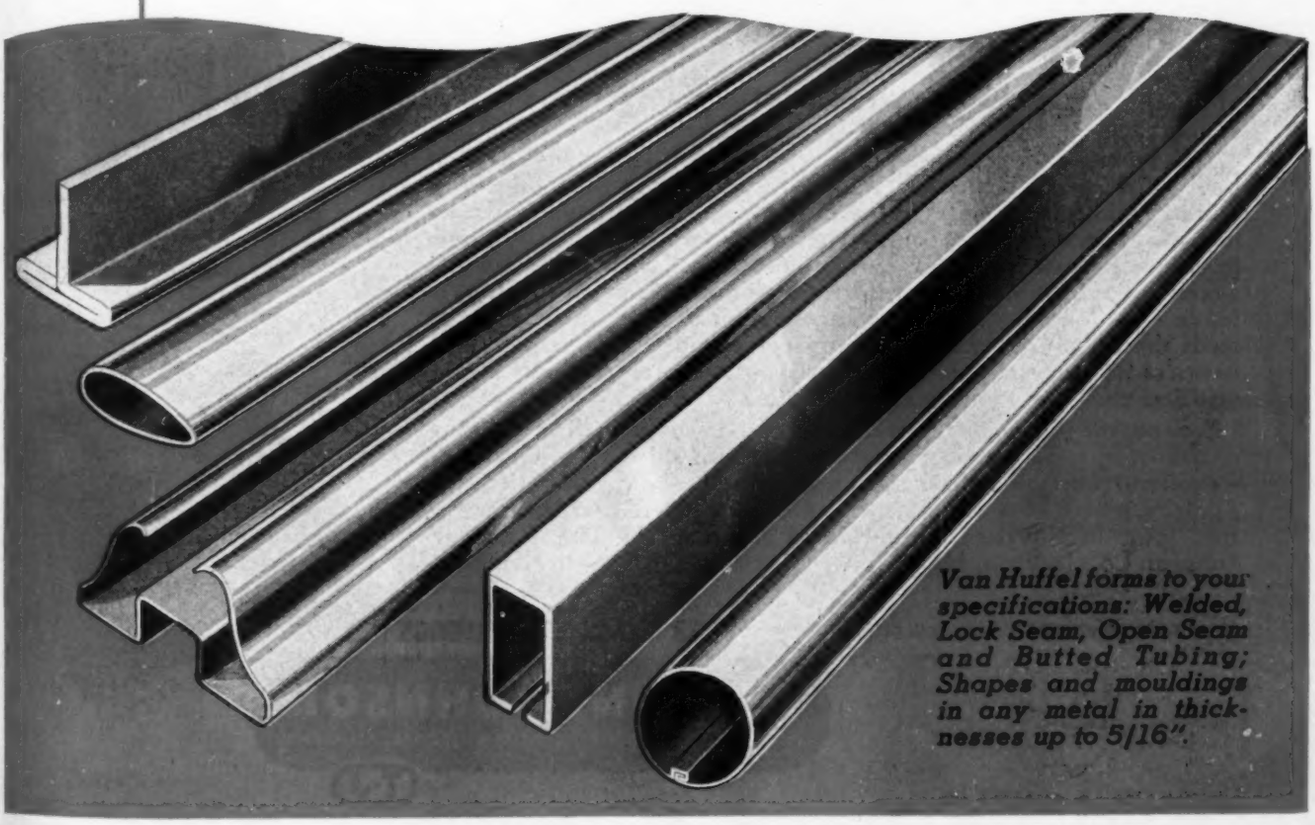
Perhaps you can use Van Huffel "know-how" and facilities to advantage. It costs nothing to find out. Write for illustrated brochure which shows the wide range and diversified application of Van Huffel Shapes and Tubing.

continuous rolled

METAL SHAPES • TUBING

VAN HUFFEL

TUBE CORPORATION · WARREN · OHIO



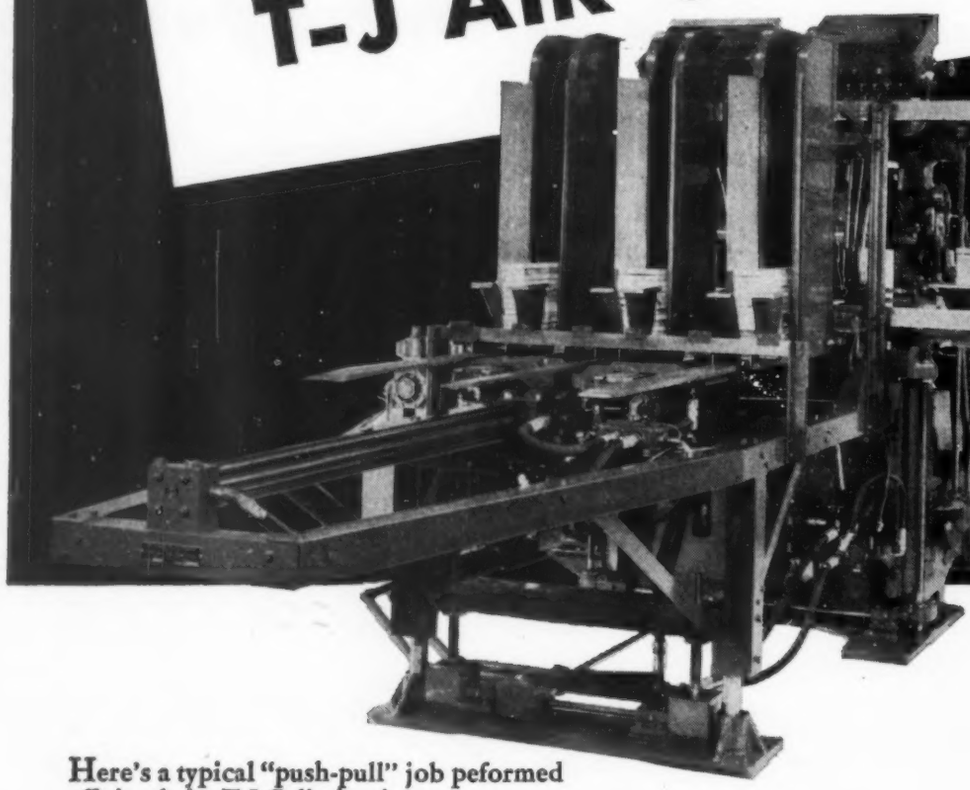
Van Huffel forms to your specifications: Welded, Lock Seam, Open Seam and Butted Tubing; Shapes and mouldings in any metal in thicknesses up to 5/16".

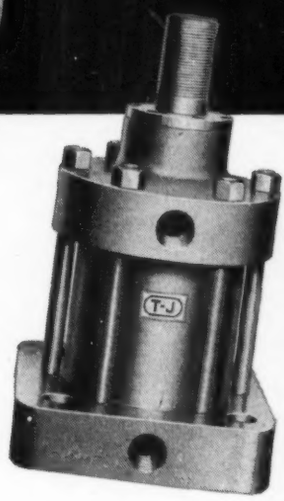
Job File No. 4617

NAILING MACHINE

feeds wood strips automatically with

T-J AIR CYLINDERS



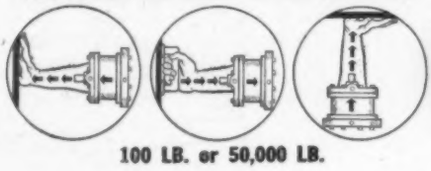


Here's a typical "push-pull" job peformed efficiently by T-J Cylinders!

This special nailing machine—equipped with T-J Air Cylinders—is built by Morgan Machine Co., Inc., Rochester, N.Y., for use by Hotpoint in Chicago. The machine is employed to make up skids for mounting electric ranges for shipment. The three boards as shown in the hoppers on top of the machine feed down one at a time while a cross piece from the hopper extended to the right of the machine is fed in. The long T-J Cylinder projecting out in front of the machine feeds the three boards ahead the proper distance and then stops to have a cross piece nailed to them. It then advances automatically to next position until four cross pieces are nailed to the three lateral strips.

For your tough jobs in power movement — pushing, pulling or lifting —*save labor, speed production* and *cut costs* with T-J Air and Hydraulic Cylinders! Many standard sizes and styles . . . both cushioned and non-cushioned types . . . 100 lb. or 50,000 lb. Precision-built, versatile, long life. Write for additional information. The Tomkins-Johnson Co., Jackson, Mich.

FOR POWER MOVEMENT IN ANY DIRECTION



100 LB. or 50,000 LB.

33 YEARS EXPERIENCE

TOMKINS-JOHNSON

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

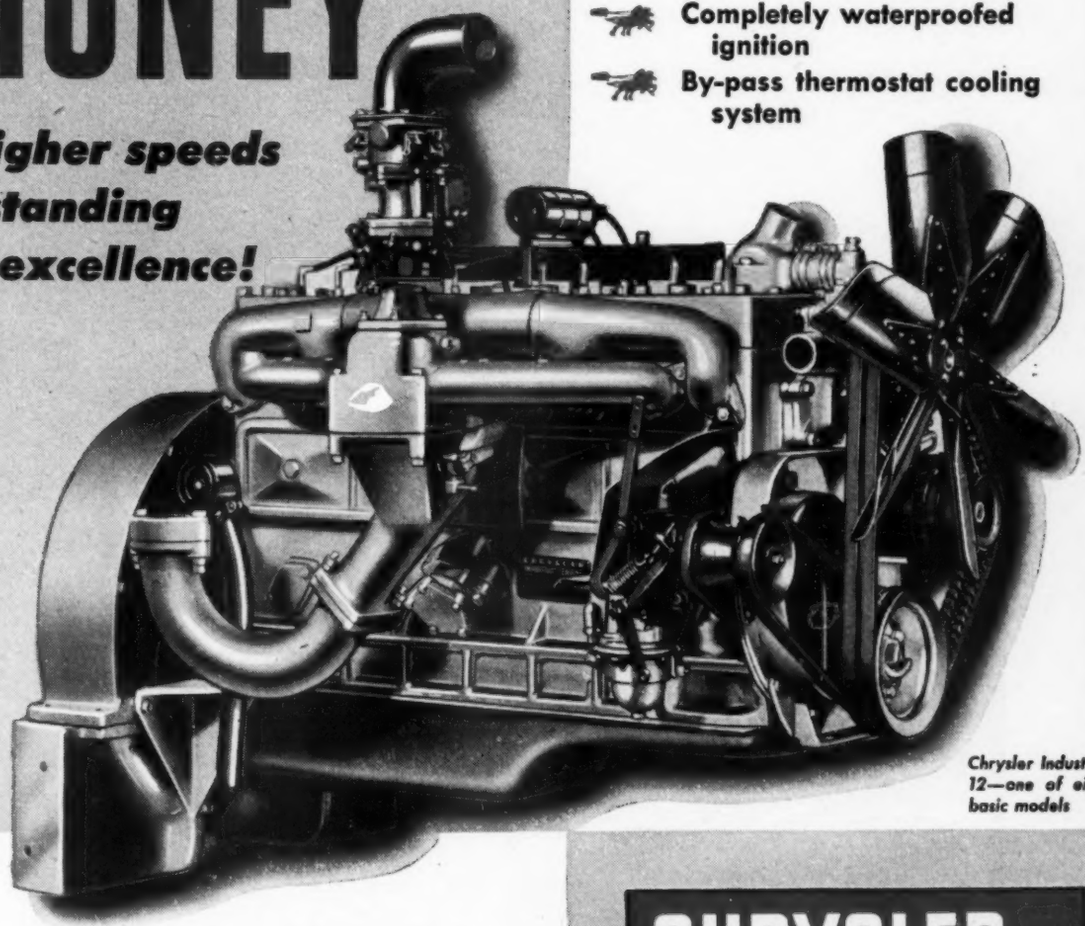
T-J

MORE POWER FOR LESS MONEY

assured by higher speeds and outstanding mechanical excellence!

Check these Features!

- All friction surfaces *Super-finished*
- Statically and dynamically balanced crankshaft
- Sodium cooled exhaust valves
- Stellite exhaust valve seat inserts
- Stainless steel valve springs
- Chrome top piston ring
- Completely waterproofed ignition
- By-pass thermostat cooling system



Chrysler Industria
12—one of eight
basic models

THE FACT that a higher speed engine can out-perform all others has long been established. Today, after years of field operation in every type of gasoline powered equipment, it has been conclusively shown that Chrysler Industrial Engines *out-last* and *out-economize* all other similarly rated engines. The reason lies in the outstanding achievements of Chrysler engineering and Chrysler research in higher alloy steels. And because of Chrysler mass production Chrysler Industrial Engines *cost less!* See your Chrysler Industrial Engine Dealer, or write us. ***Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.***

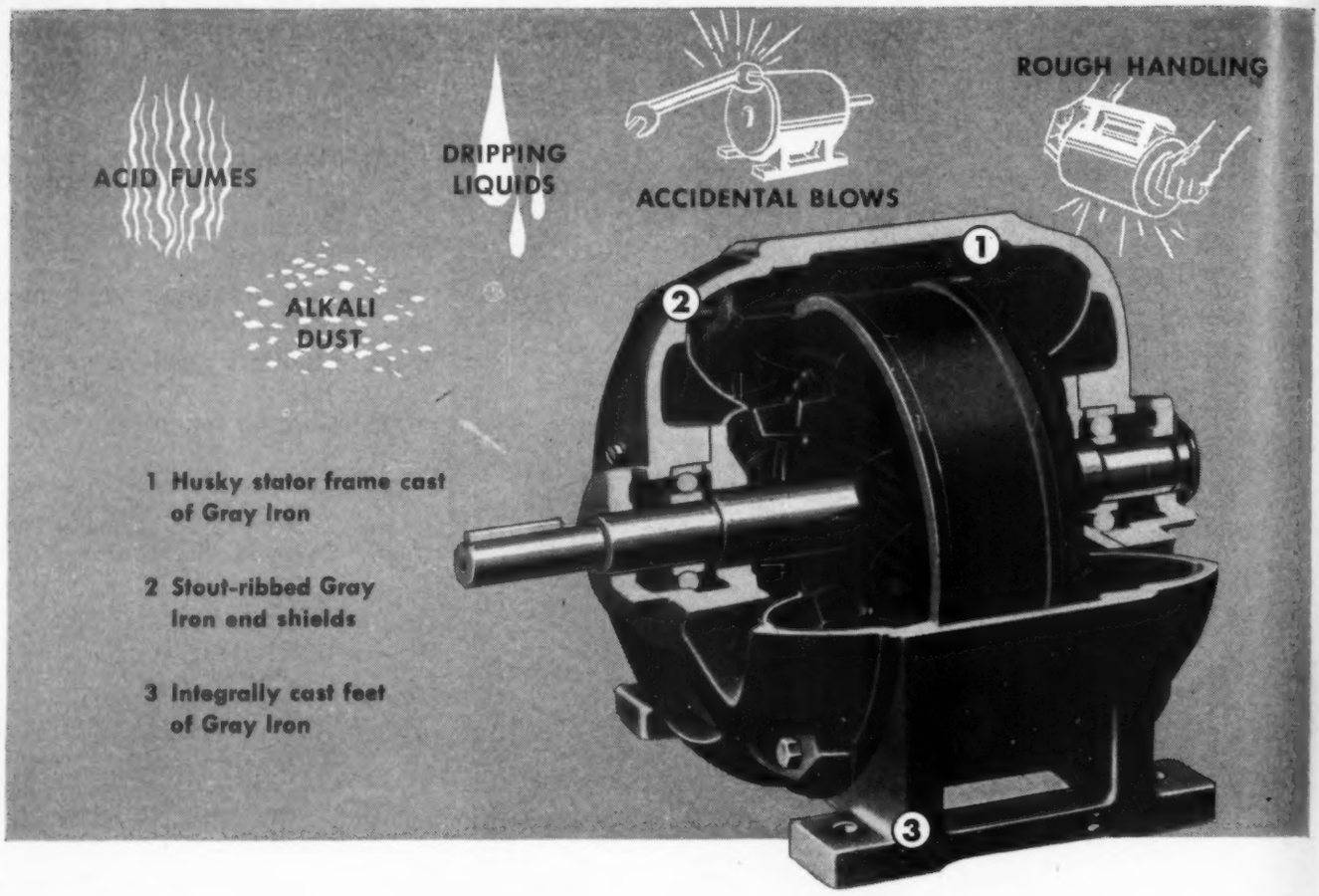
CHRYSLER

Industrial Engines and Power Units

CHRYSLER INDUSTRIAL ENGINES

HORSEPOWER WITH A PEDIGREE!

Service Available Everywhere



Where motors get ROUGH USE GRAY IRON can take it!

Typical motor end plates cast of Gray Iron

Leading motor manufacturers use Gray Iron for the following important reasons:

- Damping action that minimizes noise and vibration.
- Rigidity which insures permanent shaft alignment.
- Extra protection against jarring blows and rough handling.
- Resistance to rust and corrosion.

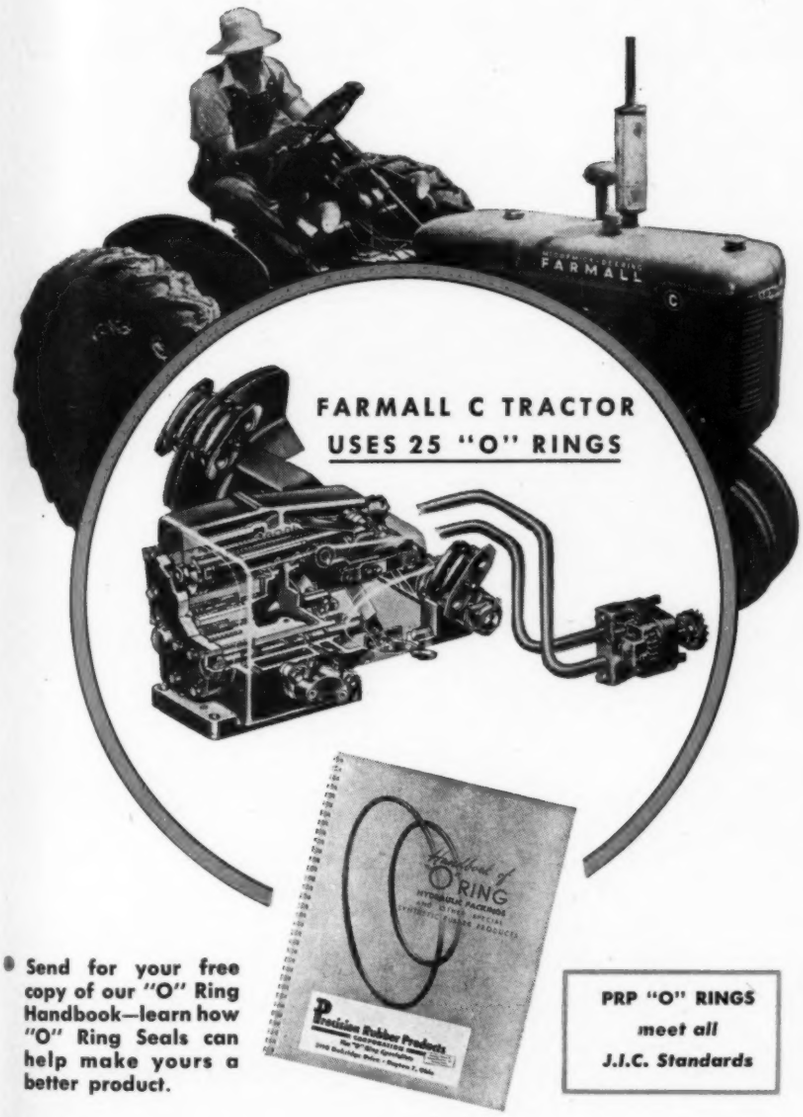
Why not take a tip from leading manufacturers and specify Gray Iron where your product must stand up under rough usage? Whether it's corrosion, abrasion, heat or vibration . . . Gray Iron can take it!

Make It Better with Gray Iron . . . Second largest industry in the metal-working field.

GRAY IRON FOUNDERS' SOCIETY, INC.
NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO

EASY DOES IT!

...with "O" Ring Seal Designs!



Send for your free copy of our "O" Ring Handbook—learn how "O" Ring Seals can help make yours a better product.

PRP "O" RINGS *meet all J.I.C. Standards*

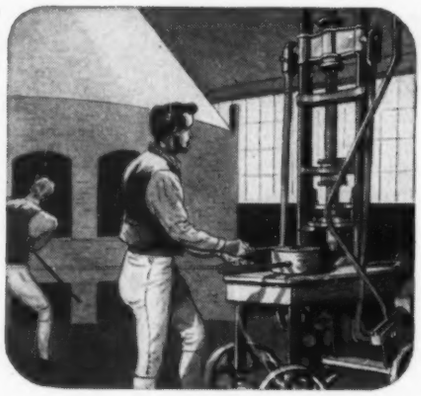
An outstanding feature of the new INTERNATIONAL HARVESTER COMPANY Farmall Cub, Super-A and C Tractors is the built in, package type, Touch-Control hydraulic system which actuates the mounted implements.

Precision Rubber Products Corporation has long cooperated in the adaptation and has been the major supplier of the 25 "O" Ring Seals (15 of them moving) that are used to seal the hydraulic fluid in the system and assure effortless and instantaneous control of the implements.

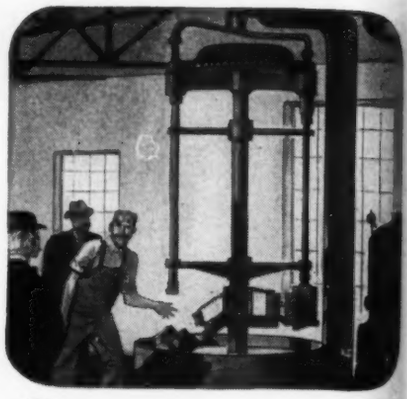
"O" Rings are economical, reliable, will save weight and space. They will help simplify your product and your production problems. PRP "O" Rings are made from a number of special synthetic rubber compounds. Let us select and recommend the best compound for service with your fluid. Why not ask PRP engineers to help you with possible adaptations? WRITE TODAY!

Precision Rubber Products
CORPORATION
Formerly Plastic & Rubber Products, Inc. Dayton, Ohio
The "O" Ring Specialists
Box 431, Dayton 1, Ohio

1 **1621**—Glass was money! America's first glass factory was actually a mint—not for the manufacture of coins but to make glass beads for *use* as money when buying land, food and furs from the Indians.



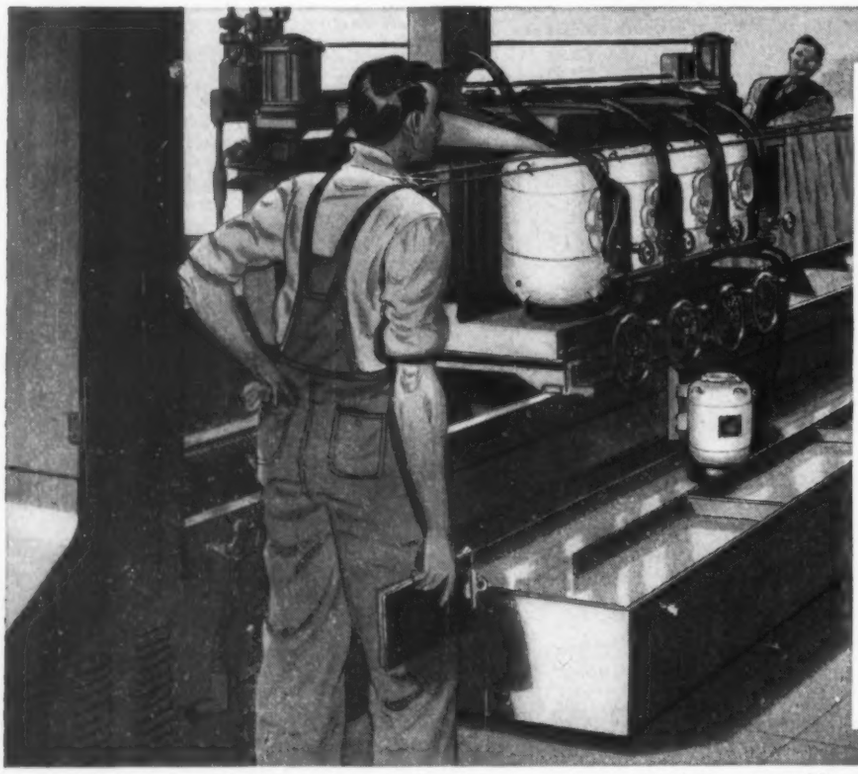
2 **1827**—Blown glass was the rule until Enoch Robinson, a carpenter, figured glass could be *pressed* into shape . . . the glass pressing machine was born. Electricity to power new machines was still to come.



3 **1899**—Owens invented a machine to make bottles as the machine age arrived in glass. By 1915, Howell "Red Band" Motors were making important contributions to this and other industries.

ANOTHER HOWELL SUCCESS STORY

GLASS...from artisans to automatic machines



4 **Today**—Modern, electrically driven machines have improved quality, cut costs and increased output in the glass making industry. For example, this unique glass beveling machine, equipped with 7 dynamically balanced Howell Motors, *automatically* bevels glass at the rate of 2,000 inches per hour!

You'll also find precision-built Howell Industrial Type Motors powering bottle and bulb machines, conveyors, grinders, polishers, plate and window machines in the glass industry.

Elsewhere, Howell's wide range of standard NEMA motors, and special motors designed to customer requirements, serve dependably and efficiently under the toughest conditions.

For a really profitable investment, buy HOWELL!

Free enterprise encourages mass production, supplies more jobs — provides more goods for more people at less cost.

Howell totally enclosed, fan-cooled motor—windings completely sealed against dirt and weather.

HOWELL MOTORS

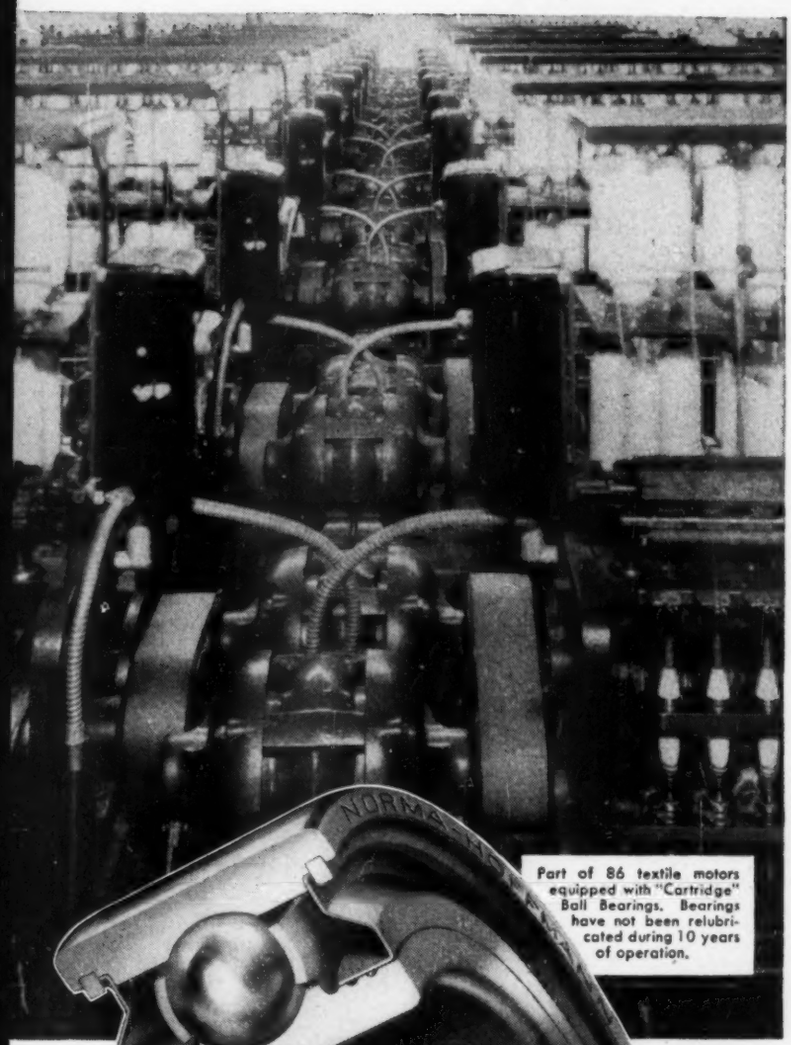
HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built Industrial Motors Since 1915

HOWELL Red Band MOTORS

CASE HISTORY #819

646 Motors Operate 8 to 10 Years Without Relubrication or Bearing Failures ...and they're still going strong



Part of 86 textile motors equipped with "Cartridge" Ball Bearings. Bearings have not been relubricated during 10 years of operation.

Norma-Hoffmann

Patented "Cartridge" Bearings increase the "Life-Span" of Equipment

Records prove that Norma-Hoffmann "Cartridge" ball bearings give continuous performance in hundreds of applications without failure.

For example — 646 motors in 5 textile mills have been operating practically continuously for 8 to 10 years without relubrication. On inspection of many of the motors, the bearings showed no appreciable wear and the original grease was in good condition for many more years of operation.

Made to double-row width, Norma-Hoffmann "Cartridge" bearings have 100% more grease capacity than conventional width sealed bearings. The highly efficient seals keep dirt out, grease in. Factory-packed with Norma-Hoffmann's specially compounded "stability-tested" grease . . . grease that is highly resistant to oxidation and breakdown . . . assures dependable operation for long periods without regreasing.

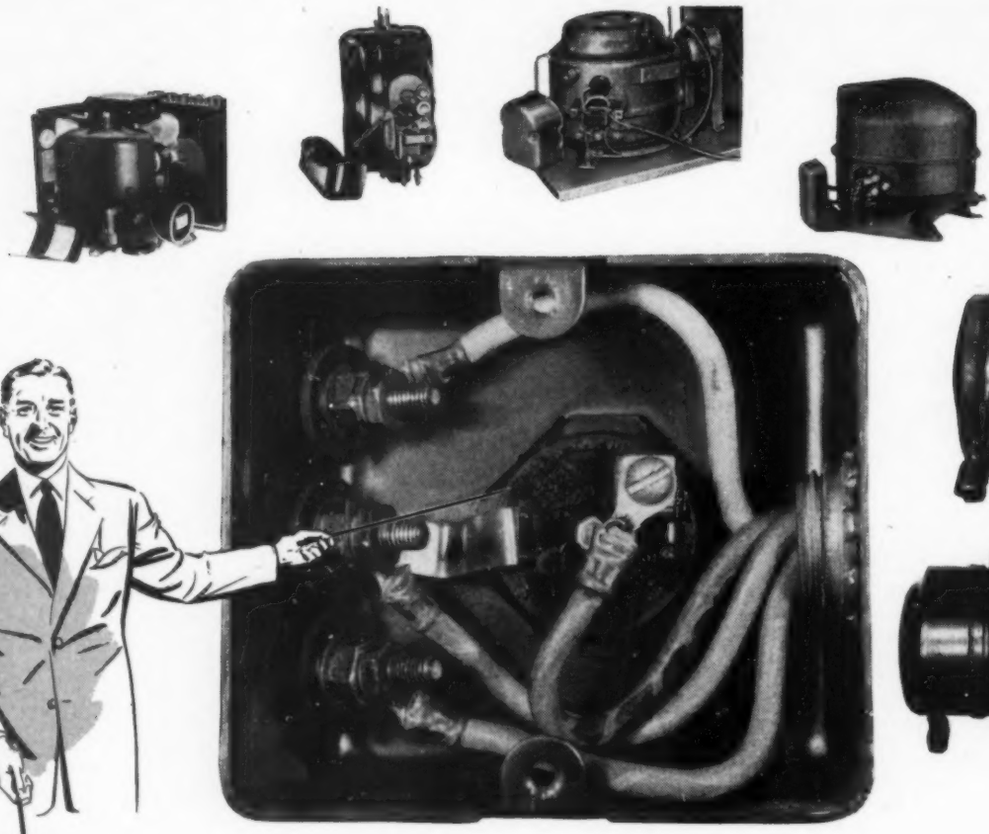
Investigate the "Cartridge" ball bearing for your products whether they be motors, machine tools, pumps or other machinery. Our engineers are always available for consultation about your bearing applications. Write for their services.

NORMA-HOFFMANN *Precision* **BEARINGS**

BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONNECTICUT

FIELD OFFICES: CHICAGO • CLEVELAND • DETROIT • CINCINNATI • LOS ANGELES • SAN FRANCISCO • DALLAS • SEATTLE • PHOENIX



Another Hermetic Unit Gets

Positive Burnout Protection

WITH

KLIXON *Dome Mounted* PROTECTORS

Illustrated, above, is the installation of a Klixon Dome-Mounted Protector in a well-known hermetic unit. Actual operating experience proves that the units protected by Klixon Protectors give years of trouble-free service without burning out.

Here's why — mounted on the dome where they follow every motor temperature change, Klixon Protectors shut the power "off" should the motor become dangerously overheated, regardless of the cause. Then, when the motor cools sufficiently, they snap the power "on" again automatically, enabling the unit to maintain refrigeration.

Because Klixon Protectors provide positive motor burnout protection, they enable the hermetic manufacturer and user to get maximum useable capacity from the motor. This means that smaller HP hermetic units can often be used . . . or the refrigeration capacity of the same unit can be stepped up.

Whether you use hermetic units, oil burners, or other electric motor driven appliances, it will pay you to specify motors with Klixon Protectors. They will reduce your service calls, minimize repairs and replacements . . . help you build and maintain customer goodwill.

KLIXON MOTOR STARTING RELAYS

These dependable relays complete the combination for starting and protecting the motor. Their positive action and long life eliminate starting troubles.

Used and recommended by leading Refrigeration manufacturers.

KLIXON

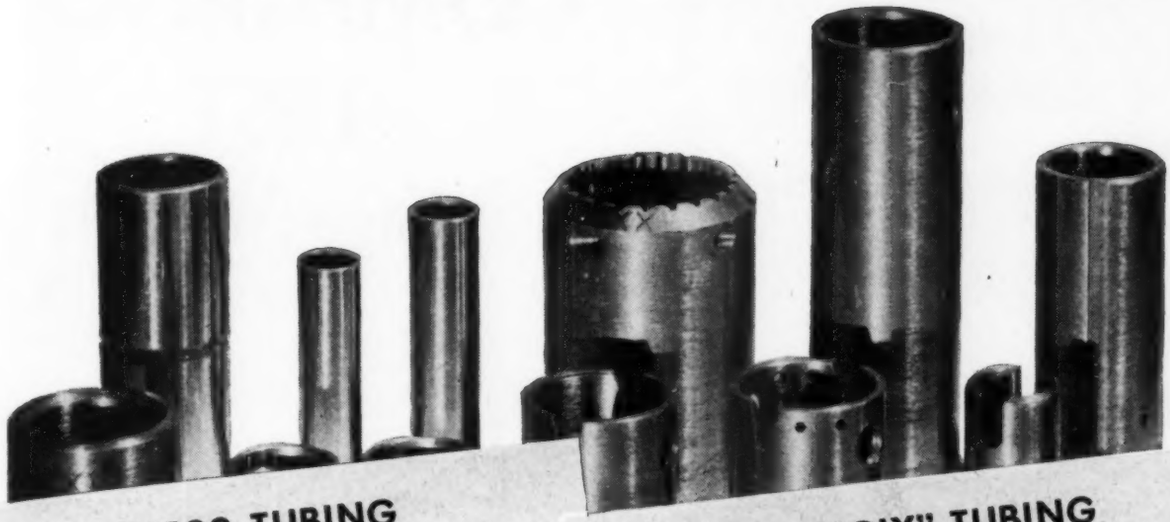
TRADE MARK REG. U. S. PAT. OFF.

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

2512 FOREST STREET, ATTLEBORO, MASS.

In a rush? Two TIMKEN® steels will do 90% of your hollow-parts jobs!



52100 TUBING

101 STOCK SIZES

HIGH CARBON CHROME STEEL—A DIRECT-QUENCHING STEEL WHICH GIVES THROUGH HARDNESS IN MODERATE SECTIONS.

Typical applications:

aircraft parts
slitter knives
bearing races
pump parts and plungers
collets
bushings
spindles
grinding machines
precision instruments

"NICKEL-MOLY" TUBING

52 STOCK SIZES

LOW CARBON NICKEL-MOLY STEEL—A CARBURIZING STEEL WHICH GIVES HIGH SURFACE HARDNESS WITH A TOUGH CORE.

Typical applications:

piston pins
bearing races
farm equipment
knitting machinery
sleeves
bushings
pump parts
perforating guns

IMMEDIATE DELIVERY OF WAREHOUSE LOTS!

WHEN rush jobs call for a little tubing in a big hurry, get in touch with Timken®. Warehouse lots of Timken 52100 tubing and Timken "Nickel-Moly" tubing can be shipped to you within 24 hours after receipt of order.

These two general purpose steels have good hardenability and wear resistance. They'll do 9 out of 10 of your hollow-parts jobs. Timken 52100 steel can be heat treated to file hardness and tempered back to any point you want. It has through hardenability in moderate sections. Timken "Nickel-Moly" is a fine-grained, carburizing steel that develops exceptional shock-absorbing qualities when heat treated.

You can depend on uniform, high quality in every shipment, too. The Timken Roller Bearing Company maintains complete, rigid quality control through every step of manufacture. For the latest information on available sizes, grades and finishes, write for stock lists. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO"

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

high voltage
Selenium Rectifiers

Make your own COMPARISON TEST

Know Which Is Best

Since most selenium rectifiers look alike, but vary greatly in quality, it is important to the user to have some simple means of determining quality. Side-by-side comparison tests are the time-honored way to compare quality. Take any 26-volt RMS selenium rectifier stack on the market—get a new G-E high-voltage stack of similar ratings and see for yourself which is the better.

These new G-E 26-volt cells thrive on comparison tests because they are outstanding in the three characteristics which mean quality in selenium rectifiers.

LOW FORWARD RESISTANCE

G.E.'s new 26-volt cells have extremely low forward resistance. This means a low voltage drop giving higher output, cooler operation, and greater rectifier efficiency. This often results in savings to you in the design and costs of other circuit components.

LOW BACK LEAKAGE

Since reverse current through a rectifier serves no useful purpose but does increase losses and heating, the low back leakage of these cells results in higher output, higher efficiency, and cooler operation.

DEPENDABLE LONG LIFE

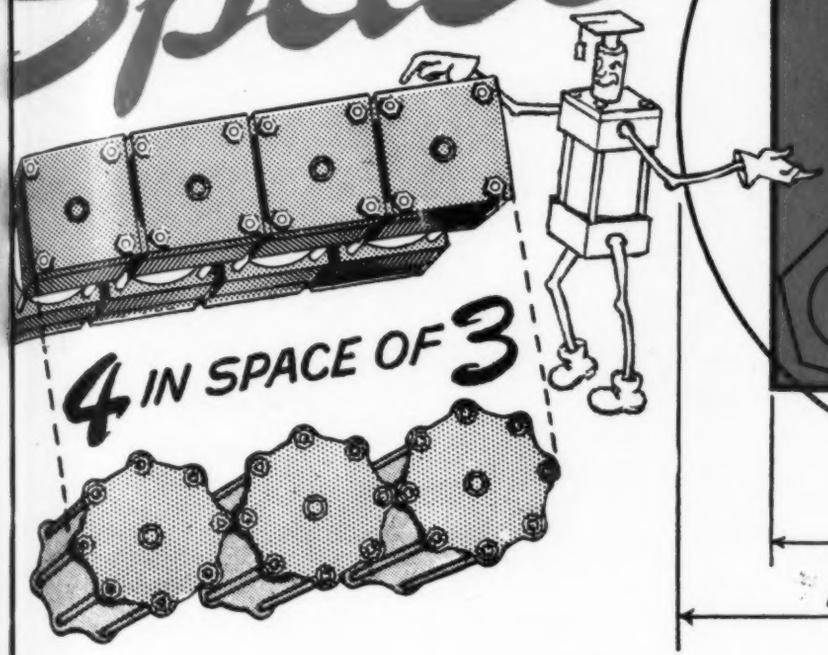
These cells are the slowest aging of any selenium cells we have tested. These dependable cells have a life expectancy of well over 60,000 hours.

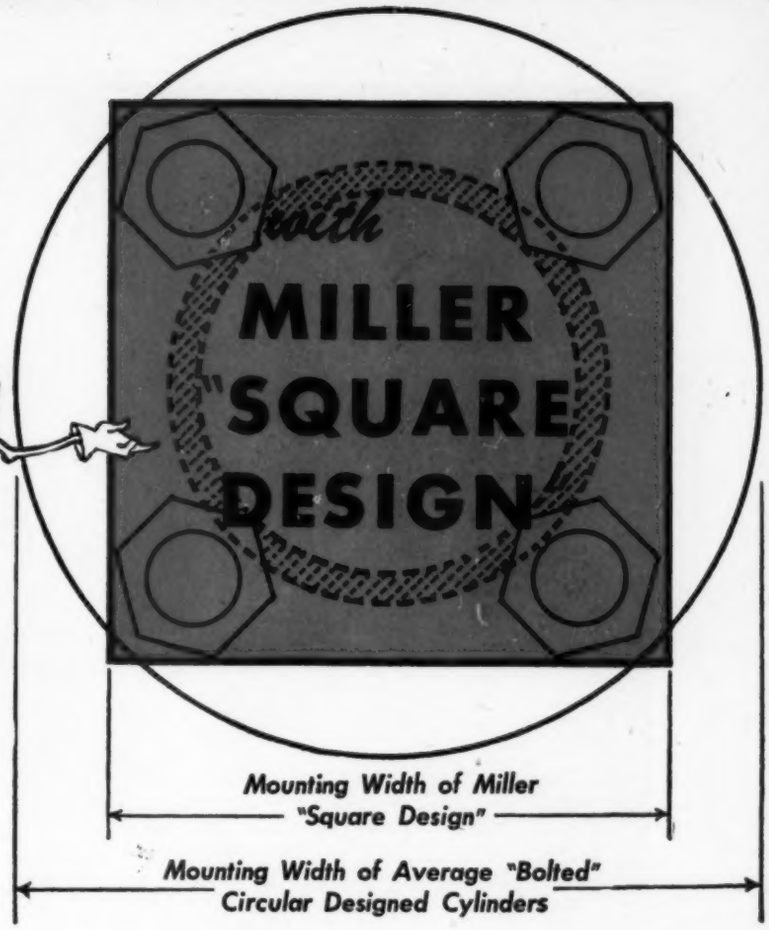
Prove for yourself the superiority of these new G-E selenium cells. *Write Section 461-13, Apparatus Department, General Electric Company, Schenectady 5, New York* for a copy of GEA-5524 which gives complete instructions for comparative testing. Contact your local General Electric Apparatus Sales Representative or authorized G-E agent to arrange your sample purchase.

GENERAL ELECTRIC

461-13

Save Space





Air *and* Hydraulic CYLINDERS...

The SQUARE DESIGN of Miller Cylinders saves up to 25% of mounting space, permitting more cylinder power in the same space and easier, more convenient installation in "tight spots." Thus, in many cases, machines and equipment can be designed more compact and less costly by using Miller Cylinders. Hours of drafting time can be saved — as only a few straight lines show any view on drawings.

The illustration at upper left shows graphically how *four* Miller Cylinders can be mounted, bore for bore, in the same space required for *three* average "bolted" circular designed cylinders. Some Miller bore sizes permit even greater space-savings.

Other important *standard* features of all Miller Cylinders include: solid steel heads, caps and mountings, hard chrome plated piston rods, dirt wiper seals, and other "quality" features as shown in illustrated bulletins sent FREE on request. Remember, too, that Miller Hydraulic Cylinders (2000-3000 psi) meet the J. I. C. Hydraulic Standards.

Write for illustrated cylinder bulletins A-105 and H-104

COMPLETE MILLER CYLINDER LINE INCLUDES: AIR CYLINDERS, 1½" to 20" BORES, 200 PSI OPERATION; LOW PRESSURE HYDRAULIC CYLINDERS, 1½" TO 6" BORES FOR 500 PSI OPERATION, 8" TO 14" BORES FOR 250 PSI; HIGH PRESSURE HYDRAULIC CYLINDERS, 1½" TO 12" BORES 2000-3000 PSI OPERATION. ALL MOUNTING STYLES AVAILABLE.

Miller
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Benefits to You!

- More Cylinder Power in Same space
- Solve "Limited Space" Problems
- Simplify Designing and Installation
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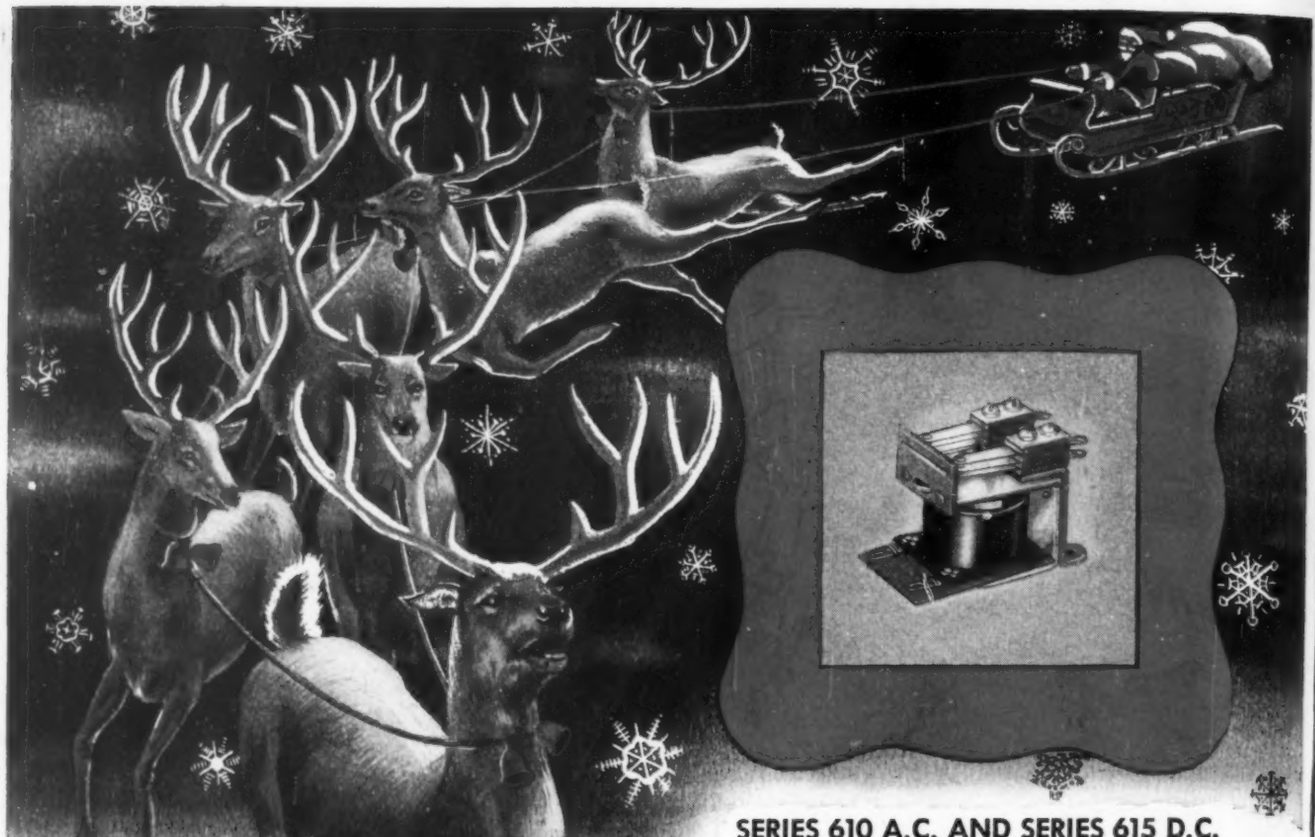

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CHRISTMAS OR CONVOYS . . . For peacetime products or national defense—let Guardian be your first line supplier.

The Guardian 610 A.C. and 615 D.C. Relay shown above is small and low priced, yet packed with power. Furnished hermetically sealed with the Screw Terminal housing shown, Octal Plug, or A.N. Connector housing.

The Guardian Hermetic Seal Screw Terminal Housing

Write— ASK US TO MAKE SPECIFIC RECOMMENDATIONS. NO OBLIGATION.

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FOR DESIGN EXECUTIVES

75. Electric Clock Movements

Sessions Clock Co.—12-page illustrated bulletin No. CM-10 contains complete information and detailed scale drawings of full line of clock timing movements. Compact design and ease of installation allow wide range of uses. Demountabe motor feature allows quick assembly and easy adjustment.

76. Air Vibrators

SPO, Inc.—8-page illustrated catalog 50 describes line of pneumatic vibrators and accessory items. Eight standard types of vibrators are covered and their over-all dimensions, weights, piston diameters and air consumption listed in chart form. Units can be used on bins, hoppers and chutes handling powdered or granular materials.

77. Self-Locking Nuts

Boots Aircraft Nut Corp.—24-page illustrated general catalog "Self-Locking Nuts" covers hexagon, anchor, floating anchor and gang channel nuts. Hex-Lok, Rol-Top, Bellows and wing styles are shown. Data on sizes, materials, heat ranges, types of anchor bases and dimensions are included.

78. Lubrication Systems

Lincoln Engineering Co.—8-page illustrated condensed catalog form 1-2470 describes standardized, centralized, mass lubrication systems for use in metal producing, metal working, mining, construction and other industries. Manual, semiautomatic and automatic systems are featured. Fittings, drum pumps, grease guns, lubricant dispensers and allied equipment are also discussed.

79. Hardfacing Alloys

Air Reduction Sales Co.—20-page illustrated catalog contains description of Airco line of hardfacing alloys and includes typical uses, mechanical properties, chemical analyses and brief outline of recommended procedures.

80. Flexible Hose Lines

Aeroquip Corp.—6-page illustrated folder No. 113 gives detailed data on line of detachable reusable fittings for flexible hose lines. Information is included on self-sealing couplings which permit separation of lines without loss of fluid. Breakaway couplings for hydraulically-operated equipment are described.

81. Investment Casting

Investment Casting Co.—4-page leaflet "The Investment Casting Process" explains method of producing tool, machine and equipment parts to tolerances of 0.005-in. per inch and varying in size from several grams to 3½ lb. How tooling, machining, design change and assembly costs are reduced is explained.

82. Rust Inhibitor

Nox-Rust Chemical Corp.—4-page illustrated circular "Protect Metal Parts" tells how Nox-Rust 310-AC removes fingerprints and deposits thin transparent film for protection against rust of metal parts in manufacture, storage or transit.

83. Research Facilities

Cook Research Laboratories—48-page illustrated brochure No. R-7 is descriptive of services, facilities and personnel of laboratories which are available to government agencies and private industry on contract basis.

84. Blueprint-Whiteprint Equipment

Paragon-Revolute Corp.—32-page illustrated catalog "Print-Making and Processing Equipment" covers line of blueprinting, diazo printing and reproduced tracing equipment for continuous yardage with automatic tracing separation and manual developer feed.

85. Vibration Absorbers

B. F. Goodrich Co.—4-page illustrated catalog section 7290 features step-by-step description of installation methods and describes Vibropad machine mounting which consists of 12-in. square rubber pad, tubes and snubbers. Pad supports feet or base of nearly any type of machinery, preventing it from transmitting jars, jolts or vibration.

86. Adhesive & Sealers

Minnesota Mining & Mfg. Co.—32-page illustrated booklet "3M Adhesives, Coatings and Sealers" tabulates properties of over 100 of these industrial materials. Also included is section covering 15 Coro-Gard protective coating systems and parts devoted to materials for shipbuilding, construction and oil industries.

87. Power Brushes

Osborn Mfg. Co.—4-page illustrated booklet describes Heli-master line of power brushes for cleaning and scrubbing prior to tin plating, Bonderizing or hot dip galvanizing and for finishing metallic and nonmetallic materials.

88. Rubber Compounds

Acushnet Process Co. — 32-page illustrated catalog No. 50 consists of three sections which include data on methods of molding, specifications and case histories on development of compounds for special applications; general properties of various rubber compounds; and plant facilities.

89. Hydraulic Components

Commercial Shearing & Stamping Co.—12-page illustrated catalog H-2 gives details of and suggested applications for oil hydraulic pumps, motors, valves and cylinders which are power operated for pressures up to 1500 psi. Wide range of sizes adapts these units to all types of equipment.

90. Direct Current Motors

Reliance Electric & Engineering Co.—12-page illustrated bulletin C-2001 offers users of ¾ to 1000-hp direct current motors design, construction, selection and other data on these units in dripproof, splashproof, totally enclosed, explosionproof, blower ventilated and gearmotors constructions. Heavy duty, constant and adjustable speed motors are described.

91. Check Valves

James-Pond-Clark—4-page illustrated bulletin "Circle Seal Precision Check Valves" gives design and application data on standard hydraulic and pneumatic check valves for working pressures to 3000 psi and temperatures from —65 to 280° F and on low pressure check valves for up to 100 psi in same temperature range. Special constructions can be furnished for temperatures to 500° F.

92. Motor Starters

Allis-Chalmers Mfg. Co.—12 and 8-page illustrated bulletins Nos. 14B6410A and 14B7303 present information on type H 2300 to 5000-v motor starters for squirrel-cage, wound rotor, synchronous and multispeed motors and type 256 air break contactor for applications requiring frequent starting, inching, reversing or dynamic braking, respectively.

93. Axial Flow Fans

Robinson Ventilating Co.—16-page illustrated bulletin 6001 on Tubeaxial fans lists capacities and static pressures of these units operating at various speeds. Dimensions and other information are given on direct and belt driven models in sizes ranging from 18 to 34 in.

94. Bearing Balls

Abbott Ball Co.—20-page illustrated bulletin contains information on bearing ball classifications and applications; selection, use and care of burnishing materials; practical barrel finishing; and lithographic plate graining.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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95. Plastics Cost Data

Monsanto Chemical Co., Plastics Div.—Pocket-size two-dial "Comparator" affords simple means for determining comparative costs of styrene and aluminum, phenolic and zinc or any contrast of plastic and other structural and fabricating materials. Reverse side of calculator gives condensed information on mechanical, thermal, electrical, optical and chemical properties of 12 leading plastics.

96. Motor-Generator Sets

General Electric Co.—8-page illustrated booklet GEA-5506 covers motor-generator sets ranging in size from 30 to 8000 kw. These machines are designed as source of direct current power for many industrial applications. Typical installations and features of synchronous motors and direct current generators are shown.

97. Hydraulic Controls

Hydraulic Equipment Co.—4-page illustrated bulletin 101 deals with Hydreco oil hydraulic control devices. Brief descriptions are included on gear type pumps, control valves, auxiliary valves, cylinder assemblies and combination pump, valve and tank units.

98. Wire Specialties

E. H. Tichener & Co.—6-page illustrated folder "Be Prepared" depicts typical wire forms, welded wire assemblies, wire and strip metal assemblies and light stampings which can be produced to specification by this company.

99. Stainless Steel Hardening

C. U. Scott & Sons—24-page illustrated pocket-size booklet explains Super Scottsonizing methods to be used in preparation of finished stainless steel parts for hardening. Parts hardened by this process retain their hardness at 1000° F.

100. Mach Number Chart

Square D Co., Kollsman Instrument Div.—"Kollsman Mach Number Chart" gives standard values for measurement of high speed in terms of Mach number, indicated air speed, differential pressure, altitude and absolute pressure. Pressure ratios, differential pressures and stagnation pressures for various Mach numbers are provided in tabular form.

101. Precious Metal Alloys

J. M. Ney Co.—20-page illustrated bulletin R-12 deals with applications of precious metal alloys for brushes, wipers, slip rings, commutator segments, resistance wire and noncorrosive wear-resistant parts in wide range of precision electrical equipment.

102. Hydraulic Actuator

Benjamin Lassman & Son—8-page illustrated bulletin No. 250 describes self-contained electrically-actuated Hydractor for applications requiring constant straight line push or pull. Models are available with standard 12-in. stroke to deliver working forces of 1000 to 4000 lb. Longer or shorter strokes can be supplied.

103. Corrosionproof Coating

Detrex Co.—4-page illustrated folder "Perm-Cote for Better Rustproofing" explains how this process creates heavy, uniform, insoluble phosphate coating on all iron and steel surfaces by chemical action. Any size or shape of part can be coated mechanically in baskets, tumbling barrels or on rack by immersing them in Perm-Cote solution.

104. Stainless Steels

Crucible Steel Company of America—32-page illustrated booklet "Making the Most of Stainless Steels in the Textile Industry" stresses advantages of various types of stainless steels for use in textile mills and points out that these types are readily weldable, free-machining and corrosion resistant. They can be bent and formed easily.

105. Industrial Fasteners

Industrial Fasteners Institute—16-page illustrated publication "Fasteners", volume six number four, delineates recent applications for improved industrial fasteners including bolts, nuts and rivets that possess ability to withstand high temperatures, vibration and other severe service conditions.

106. Motor Controls

Westinghouse Electric Corp.—20-page illustrated bulletin B-4677 demonstrates features of the new Life-Linestarter such as positive protection, ease of installation, simple maintenance, Bonderized finish, De-Ion arc quencher and flexibility of application. Five NEMA sizes cover range up to 100 hp and 600-v ac.

107. Miniature Speed Changers

Metron Instrument Co.—4-page illustrated bulletin No. 100 describes fixed-ratio type miniature speed changers in three different series for variety of applications. Standard ratios range from 10:9 to 531,440:1.

108. Welding Hose Couplers

Snap-Tite, Inc.—Illustrated bulletin and attached data and price sheets deal with Underwriters' Laboratories approved welding hose torch couplers that permit changing torches quickly and safely with simple snap on or off operation.

109. Rotary Gear Pumps

John S. Barnes Corp.—28-page illustrated loose-leaf catalog "Constant-flo Rotary Gear Pump" contains design, specification and application data on line of positive displacement rotary gear pumps for handling all types of fluids. These self-lubricating self-priming pumps are available in sizes to handle volumes ranging from 1/3 to 6 gpm.

110. Lubricating Systems

Trabon Engineering Corp.—12-page illustrated booklet "It Isn't Necessary to Lose Time Due to Bearing Failures. . ." explains how company's lubricating systems for oil and grease prevent many costly breakdowns.

111. Clutches & Transmissions

Light Inspection Car Works, V-Plex Clutch Div.—Two 2-page illustrated data sheets are descriptive of V-Plex special combination automatic transmission and clutch which enable engines or motors to come up to speed before load is applied and V-Plex clutches which are available with 2 to 2½-in. diameter pulleys for 1½ to 3-hp loads.

112. Standby Power Plants

D. W. Onan & Sons, Inc.—4-page pocket-size folder entitled "When Power's Off. . . . You're Safe" tells how standby generator designed for tractor belt drive can protect any business, factory or institution against property damage, production losses or danger to human life that might result from electric power failure.

113. Compression Fittings

Dresser Mfg. Div., Dresser Industries—12-page illustrated form No. 505 deals with flexible compression fittings that permit joining up to 2-in. pipe without threading. Twelve typical uses in case history form are cited to show wide application.

114. Production Parts

Ex-Cell-O Corp.—6-page illustrated bulletin No. 36151 depicts and describes company's facilities and services for volume production of miscellaneous production parts and sub-assemblies for clients' products.

115. Small Socket Screws

Bristol Co., Mill Supply Div.—6-page illustrated bulletin No. 881 deals with multiple-spline socket cap and set screws as small as No. 2 wire size.

116. Hydraulic Pumping Units

Denison Engineering Co.—4-page illustrated data sheet PU-2 describes two sizes of HydrOILic pumping units that can be used to provide from 400 to 2000-psi hydraulic pressures and from 3.5 to 11-gpm volumes for controlling power to HydrOILic power heads or other hydraulic devices within their pressure range.

117. Speed Reducers

Michigan Tool Co., Cone Drive Gears Div.—4-page engineering bulletin 789-50 gives basic general information on standard Cone-Drive speed reducers and gear sets ranging between 5:1 and 70:1 ratio and in capacities from 0.05 to 555 hp.

118. Packaged Cutoff Wheels

Chicago Wheel & Mfg. Co.—6-page illustrated folder "Moisture-free Chicago Cut-Off Wheels" explains how moistureproof packaging delivers wheels to user in factory-fresh condition to assure long life and fast cutting action.

119. Repulsion Motors

Miehle Printing Press & Mfg. Co., Star Kimble Motor Div.—2-page illustrated bulletin B-302 describes 1/6 to 3-hp continuous-duty single-phase repulsion motors. Illustrations of various models and of different speed and operating remote controls as well as data on current consumption at various speeds are included.

120. Aluminum Cable

Reynolds Metals Co. — 16-page illustrated booklet briefly describes operations at company's Listerhill, Alabama plant where alumina is processed into aluminum sheet, foil, cable, wire, rod, bar and other aluminum products. Production of steel-reinforced aluminum electric cable is explained and operations depicted.

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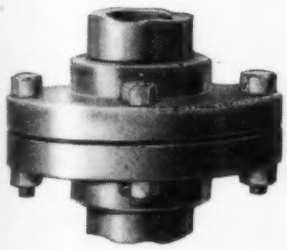

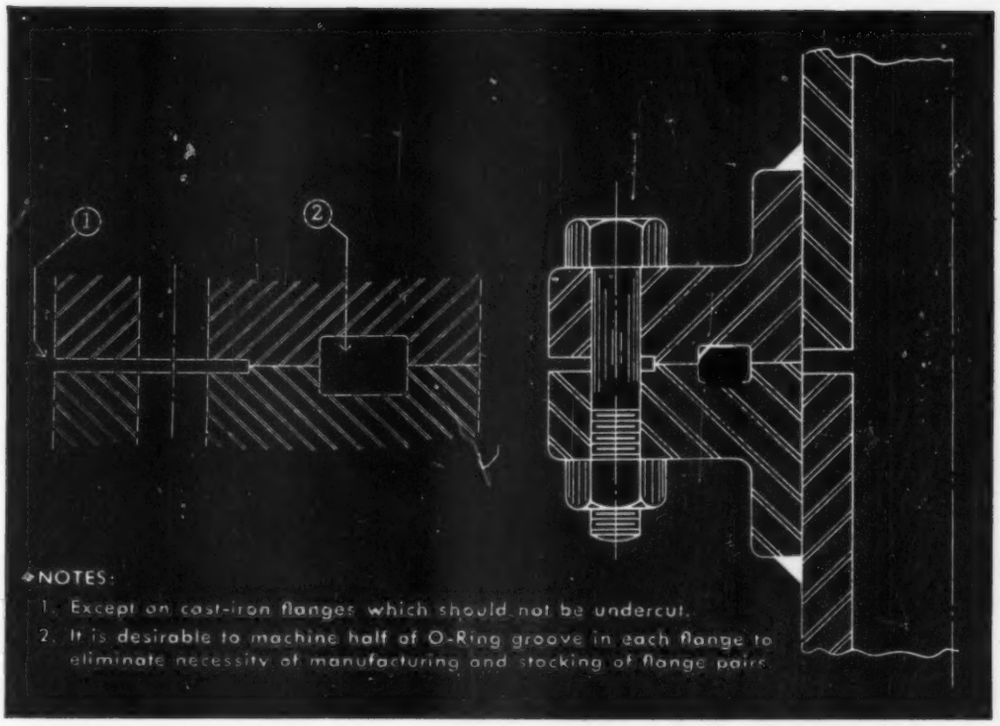

TIP...

FOR THE DESIGNER

Eliminate Guesswork! Bolt Metal-to-Metal with...

LINEAR PRECISION MOULDED "O" RINGS

You get a perfect seal with only metal-to-metal contact between flanges when you use a Linear "O" Ring Gasket. There's no more need for straining at bolts . . . and no more need for periodic checking or tightening.

Linear "O" Rings are easily installed, without special assembly tools or gasket paste. They maintain a positive seal in spite of vibration. They cannot be unduly squeezed or damaged by over-tightening. They enable a reduction in the number of bolts required for a leak-proof seal. They eliminate expensive shut-downs and repairs created by inopportune gasket failure. And, they take the guesswork out of the effectiveness of your flanged connections . . . help you standardize on one simple, efficient, maintenance-free method.

Linear "O" Rings are compounded of natural or synthetic rubber, fluorethylene polymers, and silastics . . . are available in a complete range of J.I.C. and A.N. standard sizes, as well as hundreds of non-standard sizes for special uses. For specific help with *your* sealing problem . . . CALL LINEAR.

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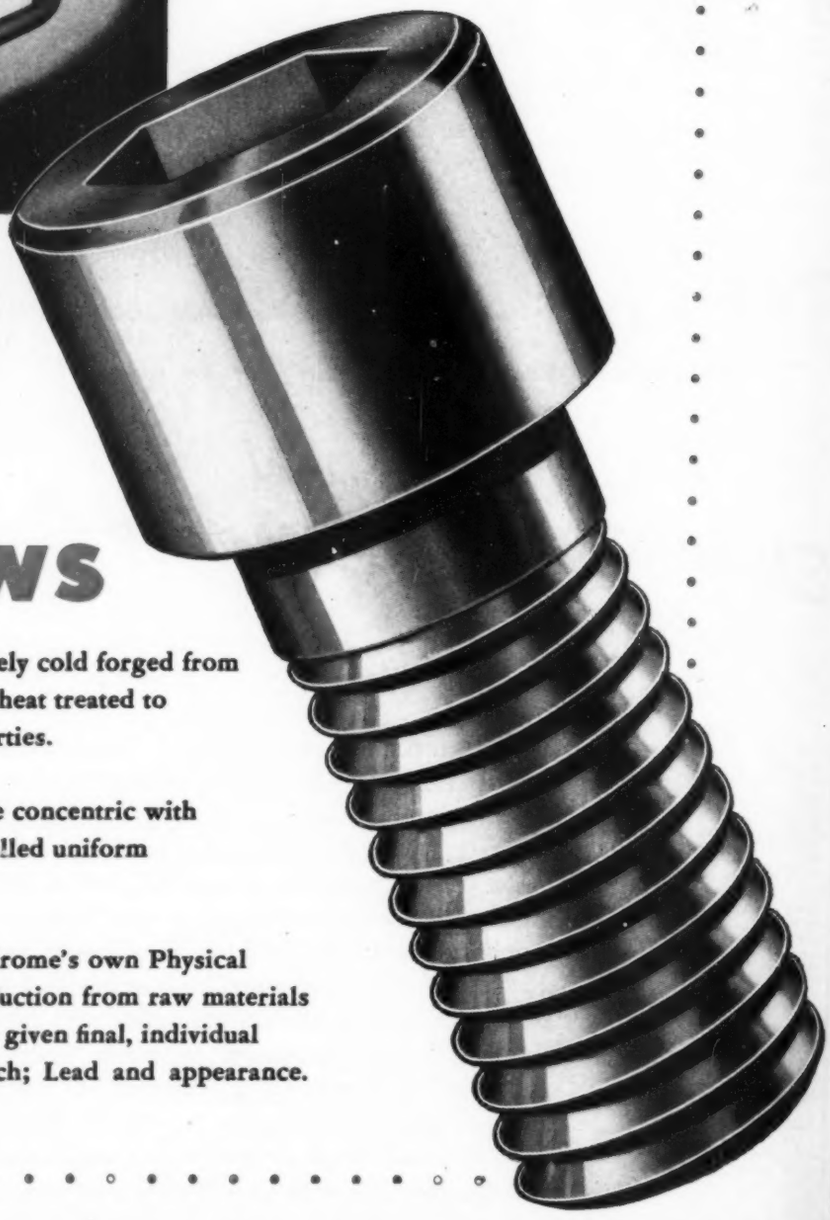

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CAP SCREWS

CONTROLLED STRENGTH—Completely cold forged from special analysis alloy steel. Scientifically heat treated to develop the utmost in all physical properties.

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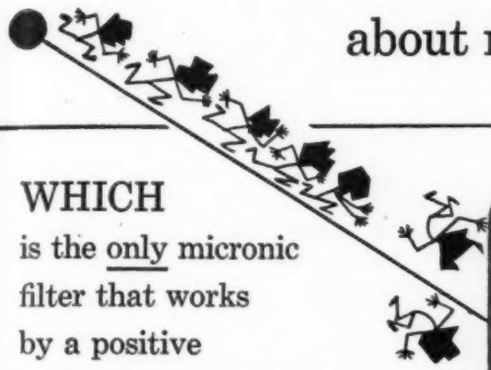
503

Which Design

answers your most important problems about micronic filtration?



WHICH

is the only micronic filter that works by a positive mechanical principle?

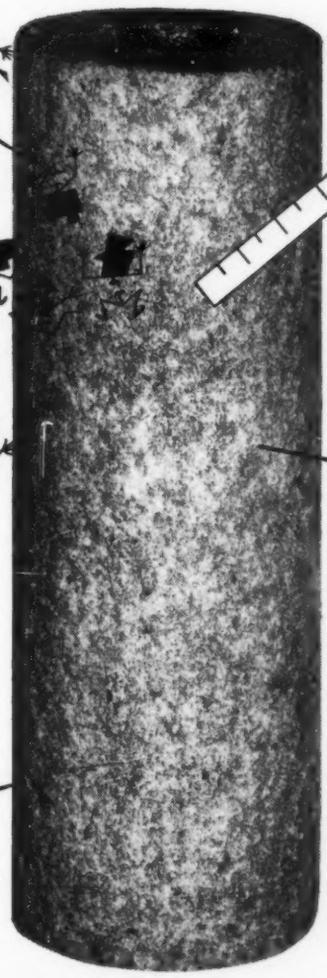
Cuno MICRO-KLEAN cartridge consists of tiny fibres distributed under scientific control and resinous impregnated and polymerized to prevent softening, swelling, hardening, shrinking, rupture or channelling. Solids are simply entrapped in the interstices—no other means is utilized. Densities: 10, 25, 50 microns. Wide range of fluids, flow rates and capacities (from a few to more than 800 gpm). Single or multiple cartridge units.

Your Customers will like . . .

Longer life—Exclusive "graded density in depth" permits smaller particles to penetrate to varying depths—doubles dirt-holding capacity.

Low pressure drop

Changing cartridge is quick—and clean.

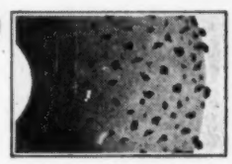


No Fluid Is Better Than Its Filtration

WHICH FILTER

needs the least amount of room?

Cuno MICRO-KLEAN cartridge is utterly simple. It's all filter, no structural components. This means less space needed—and makes *full-flow filtration* practical for either external or built-in applications.



WHICH FILTER

is guaranteed for specific performance?

Felting of fibres is accurately controlled for various densities . . . so that a Cuno MICRO-KLEAN of a given density will positively remove 100% of all solids for which it is rated, plus a large percentage down to 1 micron.

CUNO

Complete Line

Fluid Conditioning

Removes More Sizes of Solids from More Types of Fluids

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WIRE-WOUND Flo-Klean

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- ☐ Water and Water Solutions
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- ☐ Fuel Oil
- ☐ Acids

CUNO ENGINEERING CORPORATION
2014 South Vine St., Meriden, Conn.

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Company.....

Address.....

City.....State.....

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Valve seat grinder poses two distinct oil sealing problems

Two unusual shaft sealing problems are present in the rotary valve seat grinder for large gasoline and diesel engines (Fig. 1). Rotary speeds from 300 to 12,000 rpm, shaft whip, reciprocating action and extreme external abrasive conditions require oil seals of unusual dependability.

In the sectional drawing (Fig. 1), the main shaft driving the abrasive wheel rotates at 12,000 rpm. This shaft also engages a secondary worm gear to rotate the entire grinder around the periphery of the valve seat. National 50,000-S Syntech (Fig. 2) seals, spring-loaded, single wipe units are installed just inside the pre-loaded ball

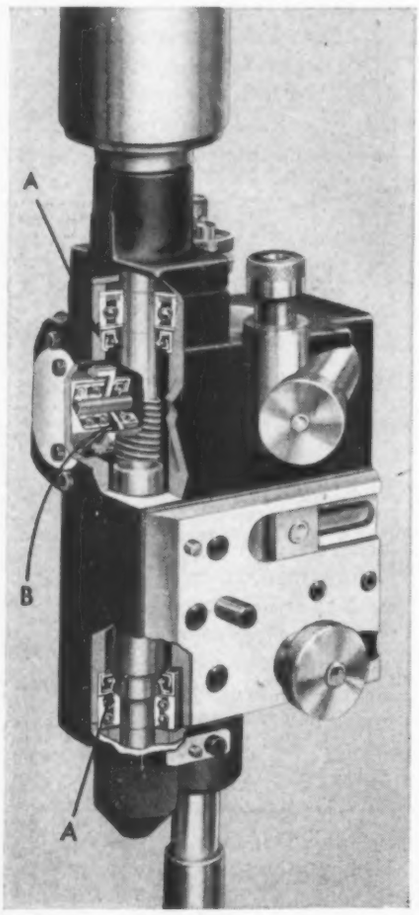

Figure 1

Figure 2

bearings (A) on the main shaft and outside the conventional bearing (B) on the horizontal shaft (in Fig. 1). These seals retain a light lubricating oil in the open double row bearing (B) and the high-speed worm gear. Even though flooding is encountered, zero leakage performance must be achieved to prevent flooding of the grinding wheel. The high speed and angle thrust on this spindle result in shaft whip, which demands flexibility in the oil sealing members. National Syntech* oil seals are ideal for this application, because their inherent flexibility and *carefully* designed flex section provide effective sealing under eccen-

Figure 3

tricities up to .025 indicator reading. The minimum-contact, carefully tensioned sealing lip insures minimum drag and dependable sealing even under continued operation at high speeds.

The section (Fig. 4) is of a wheel dressing attachment. Here shaft action is reciprocative and extreme abrasive conditions are present since the assembly is continually exposed to fine abrasive dust from the grinding wheel. Two sturdy National Syntech 340,000 series (Fig. 3) are installed here. The seals are mounted with lips facing outward (C) and serve as dust excluders. Effectiveness of the seals is attested by the fact that with hundreds of grinders in operation, no replacement has yet been required due to scored shaft surfaces or abrasive leakage.

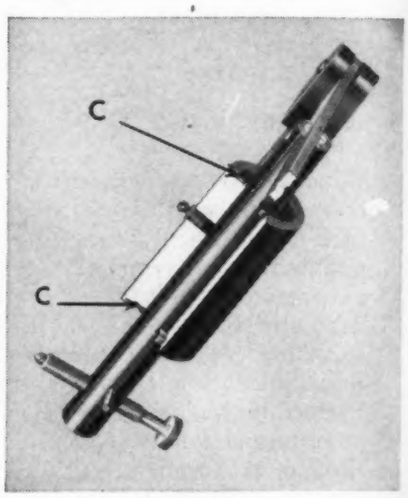

Figure 4

In many cases such as the above, sealing problems can be solved at considerable savings by using stock National Oil Seal designs. In other applications, special designs may be necessary. In either event, National Oil Seal engineers are ready to assist you.

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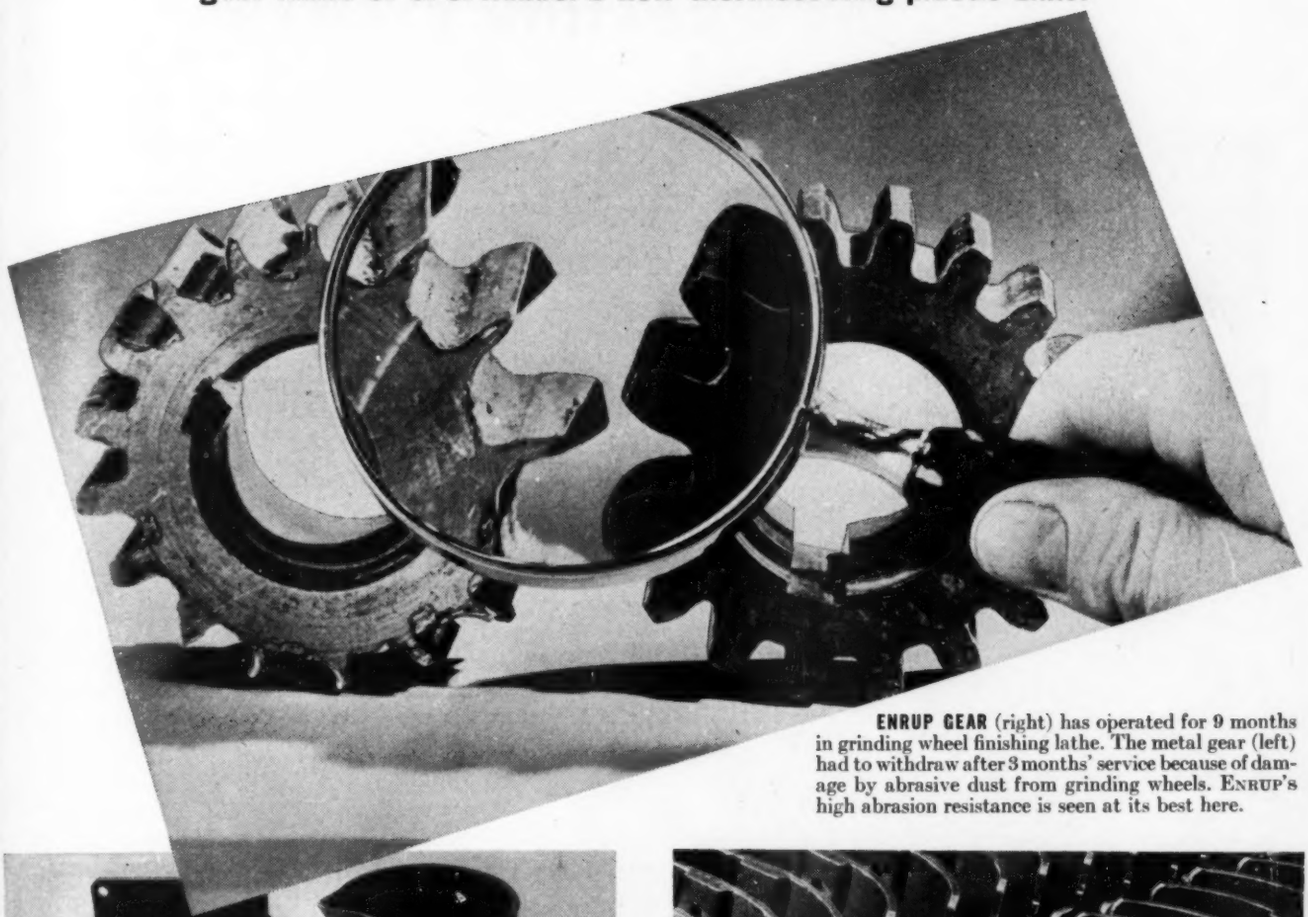
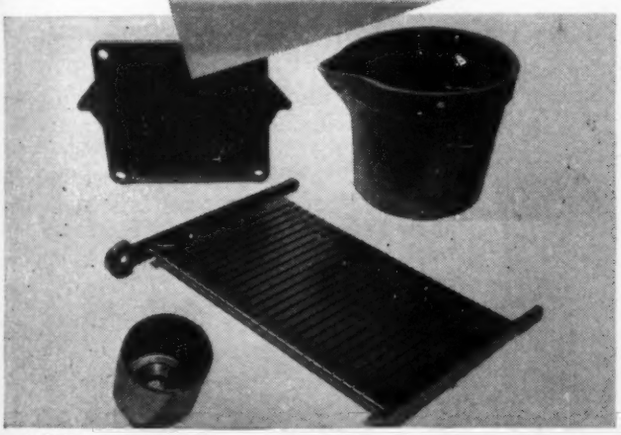


ENRUP GEAR (right) has operated for 9 months in grinding wheel finishing lathe. The metal gear (left) had to withdraw after 3 months' service because of damage by abrasive dust from grinding wheels. ENRUP's high abrasion resistance is seen at its best here.



FILTER PRESS PLATE, upper left, and chemical bucket, right, are molded from ENRUP replacing hard rubber because of toughness, heat and chemical resistance. Center is photostat separator plate, once made of hard rubber, now made of ENRUP because of superior toughness and high impact strength. Lower left is lap roll used in the textile industry. Once made of laminated phenolic, it is now molded out of ENRUP, cutting cost by 50%.

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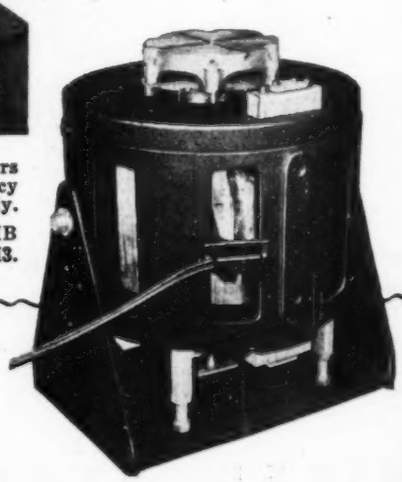

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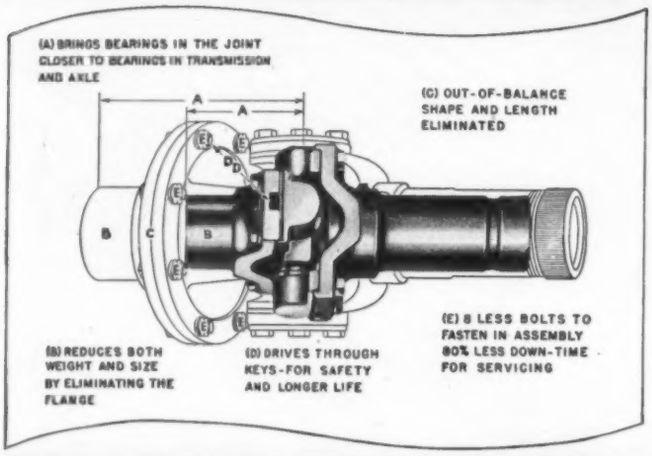

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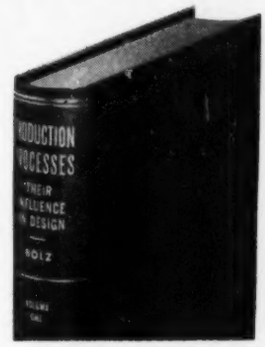

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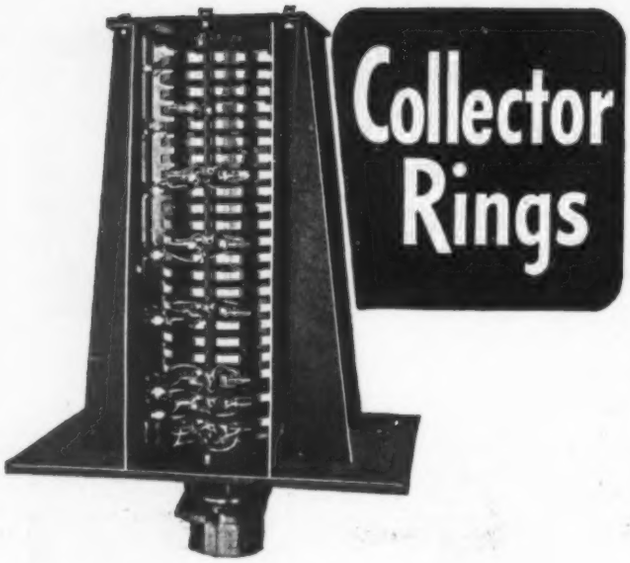

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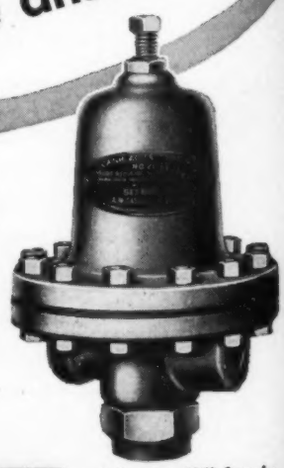

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ALL METALS: Steel, Brass, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

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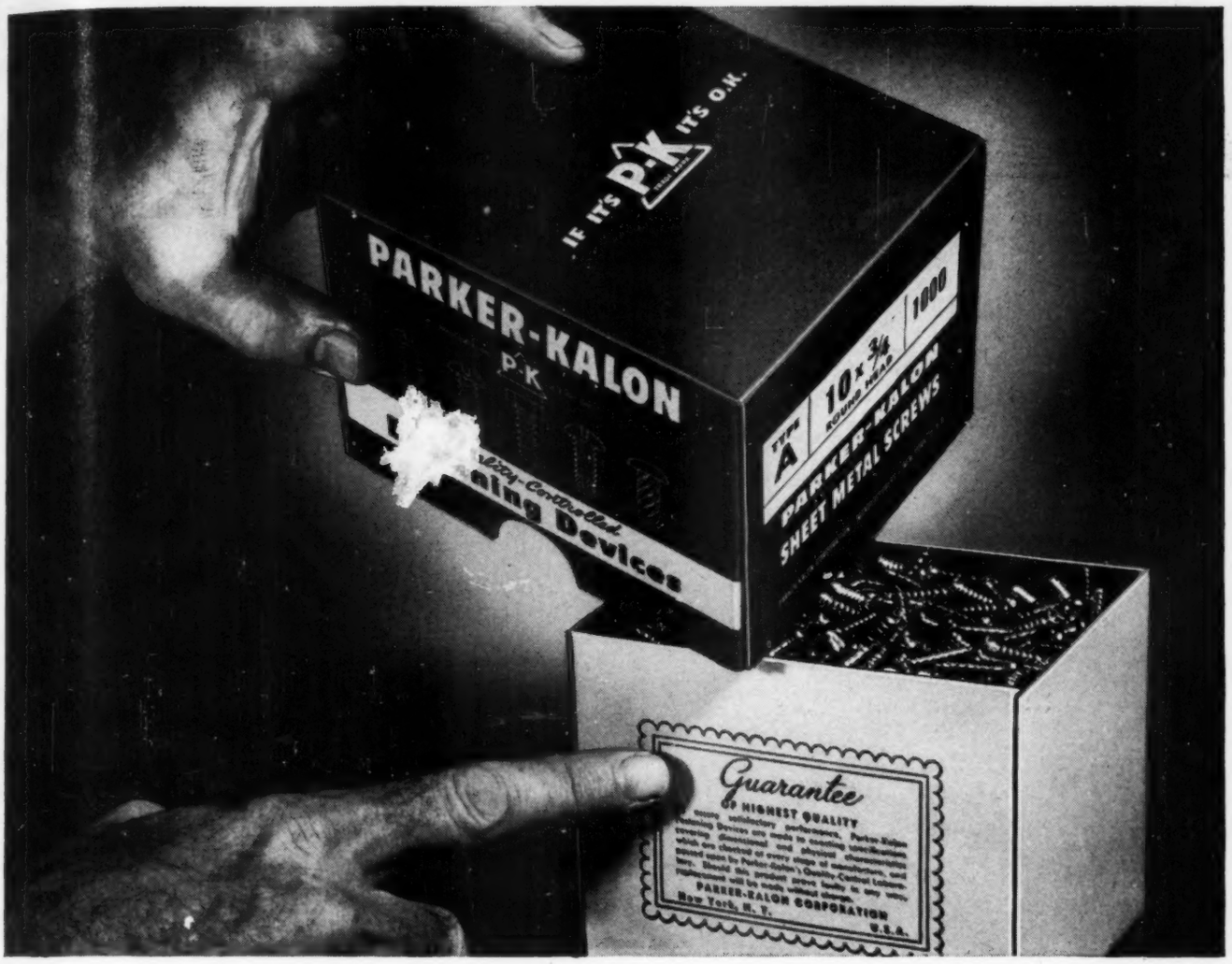

HOW TO UNCOVER EXTRA SAVINGS...

Most manufacturers today are aware of the advantages of using hardened Self-tapping Screws. They save time and simplify assembly by eliminating tapping for machine screws, by avoiding inserts in plastics, by using one operation fastening in place of bolting, riveting, soldering.

But they still may be missing some substantial *extra* savings, because all Self-tapping Screws are *not* alike. Planned savings don't always pay off.

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Start making the extra savings you've been missing. Find out why the manufacturers of so many of the nation's best known products say, "If it's P-K* . . . it's O.K.!" A P-K Assembly Engineer will call at your request. Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y. Sold everywhere through accredited Distributors.

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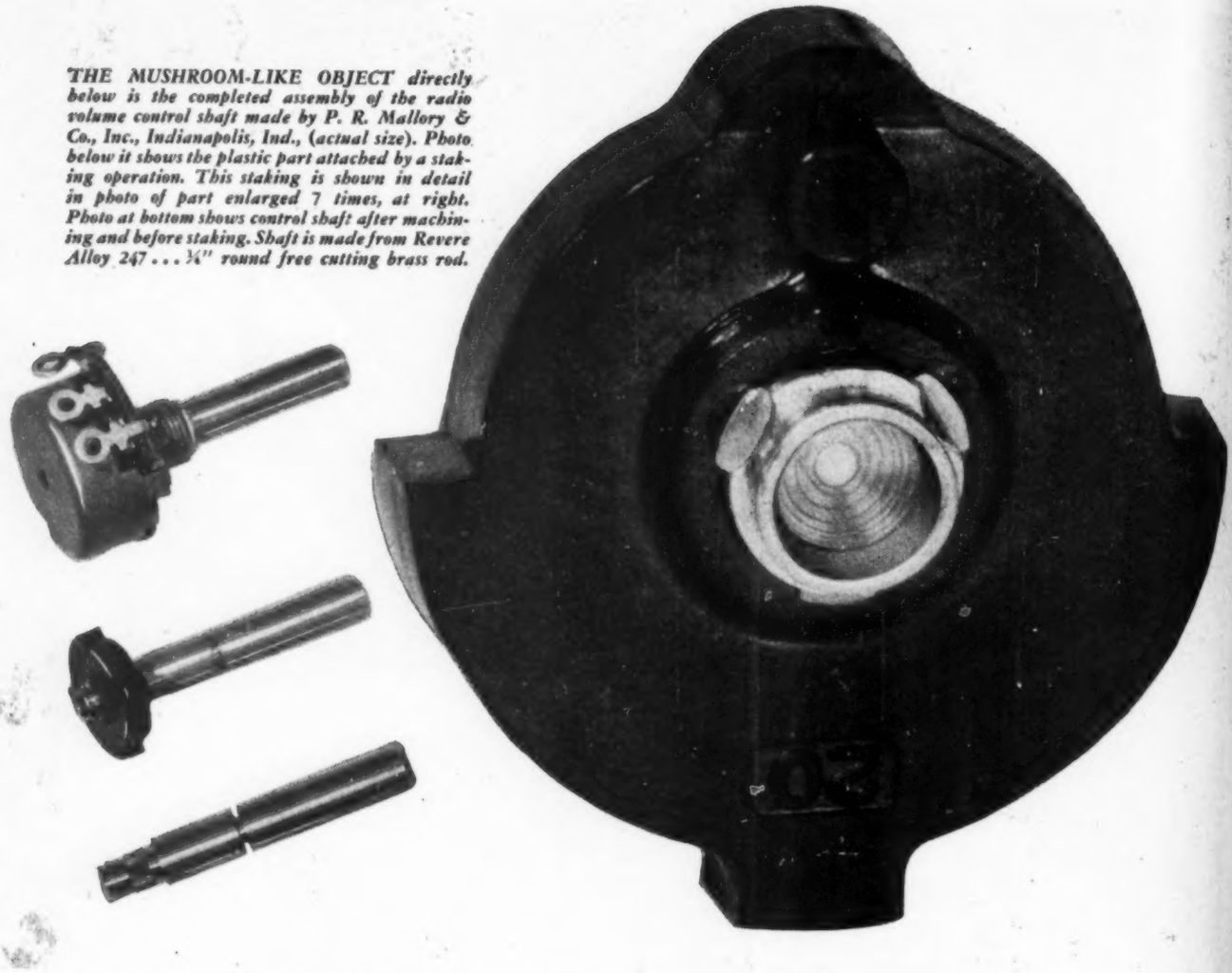
OTHER P-K PRODUCTS: Cold-Forged Socket Screws, Wing Nuts, Thumb Screws • Hardened Screwnails and Masonry Nails • Shur-Grip File and Solder Iron Handles • Metal Punches • Damper Regulators and Accessories

THE MUSHROOM-LIKE OBJECT directly below is the completed assembly of the radio volume control shaft made by P. R. Mallory & Co., Inc., Indianapolis, Ind., (actual size). Photo below it shows the plastic part attached by a staking operation. This staking is shown in detail in photo of part enlarged 7 times, at right. Photo at bottom shows control shaft after machining and before staking. Shaft is made from Revere Alloy 247 . . . ¼" round free cutting brass rod.



BY SWITCHING TO REVERE FREE CUTTING BRASS ROD P. R. MALLORY & CO., INC.,

SAVES ON 2 COUNTS!

Staking operation on radio volume control shaft performed without fracture . . . annealing operation eliminated.

The solution to the Mallory Company's problem was not as easy as it might appear. It was not simply a case of Revere Technical Advisory Service recommending ¼" round, free cutting brass rod. That rod had to possess the machinability to match Mallory's existing production machine set-up and at the same time be sufficiently workable so that annealing, prior to staking, could be eliminated; and that staking be accomplished without fracturing the metal.

After consulting with the Mallory Engineers, and discussing the tests which Mallory would subsequently conduct, Revere recommended a ¼" round, half hard riveting and turning rod mixture 247. Working tests made by Mallory showed this rod to possess all the necessary requirements.

As a result of those tests, P. R. Mallory & Company is now using this Revere free cutting brass rod to its complete satisfaction for the radio volume control shafts it manufactures. Not just any ¼" brass rod, but the *right* rod made it possible for them to save on 2 counts.

Perhaps Revere has a brass, a copper or some special alloy to help you in the development or improvement of your product . . . in cutting your production costs. So why not tell Revere *your* metal problems? Call the Revere Sales Office nearest you today.

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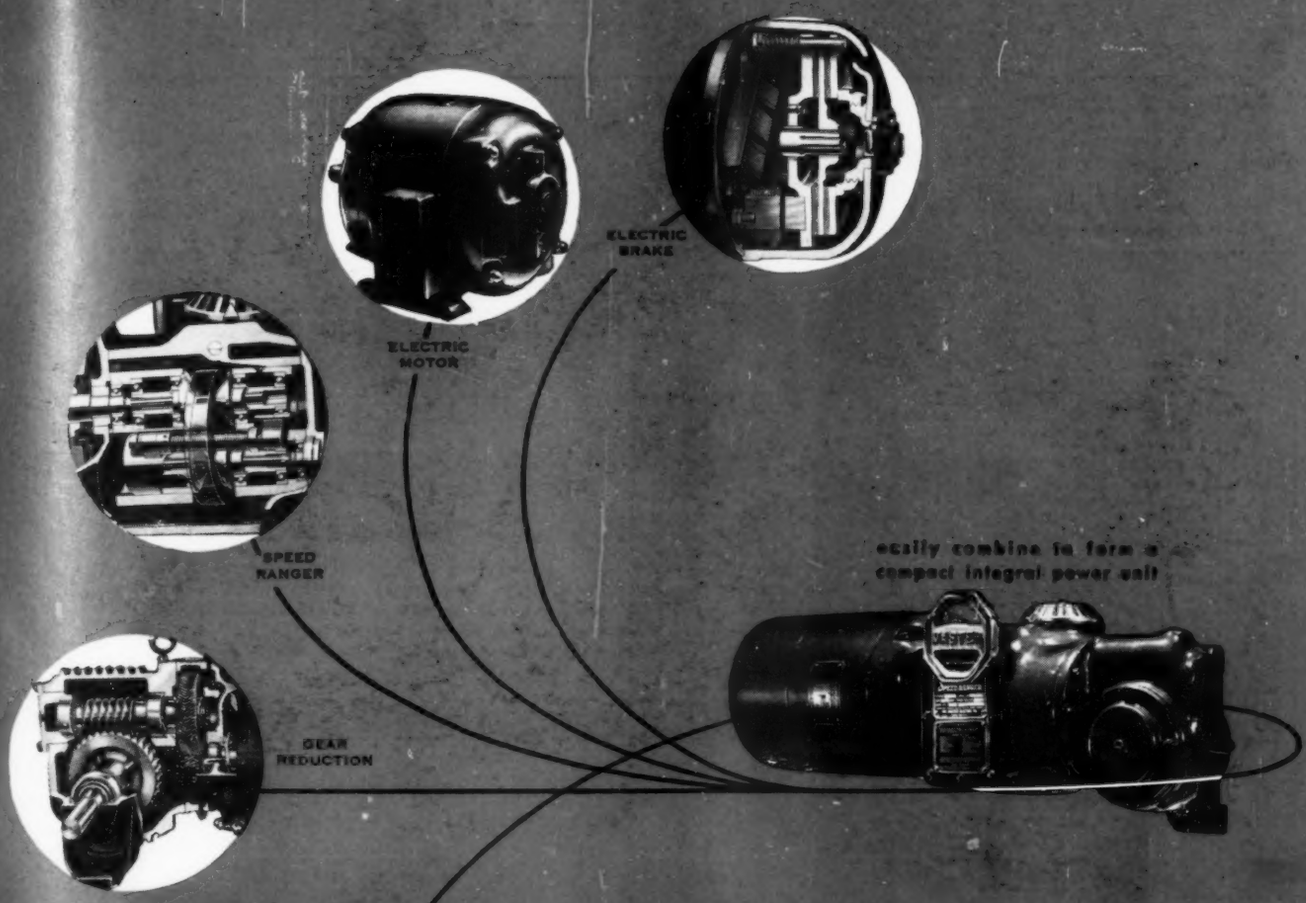

make a good job Better

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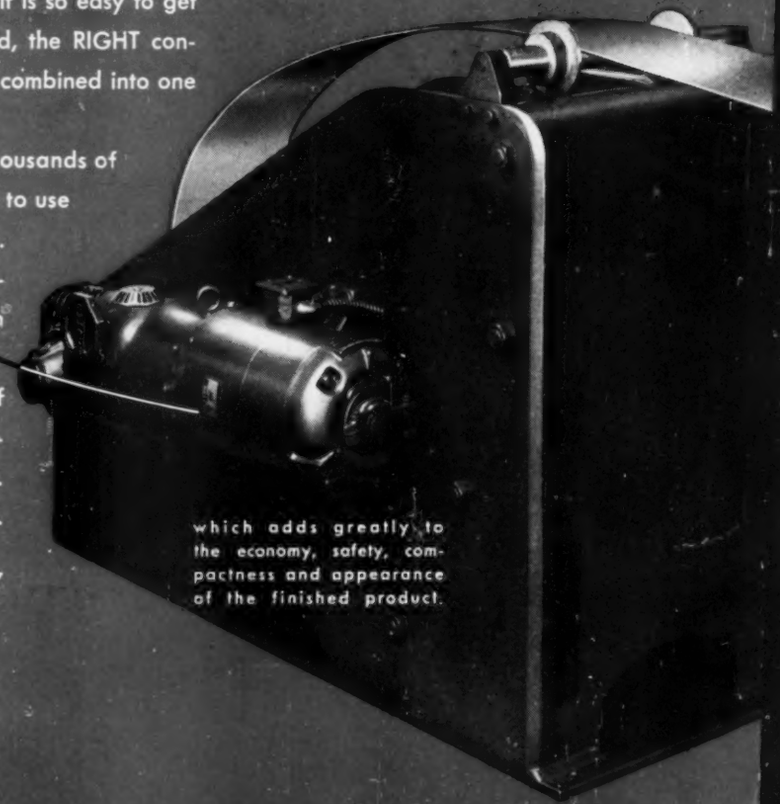

which adds greatly to the economy, safety, compactness and appearance of the finished product.

Trouble-free performance "as specified"

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Architects and consulting engineers specify Cutler-Hammer Dimmers for beautiful lighting effects in churches, school auditoriums, lodge halls, restaurants, skating rinks, hotel lobbies and ballrooms, as they do for the nation's theaters.

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The architects, engineers, and contractors who create these buildings know how much the trouble-free performance of electrical facilities means in shaping their reputations. As a consequence, Cutler-Hammer Motor Control has long been their outstanding choice for every building need. For more than a decade they have selected Cutler-Hammer Multi-Breakers as the perfect circuit protection for homes, and more recently have welcomed Cutler-Hammer Breakerpanels as the logical extension of this same protection to larger buildings. Today they are finding ever wider use for Cutler-Hammer Dimmers; not only in theaters but in churches, schools, restaurants, hotels, public buildings, even in homes . . . for beautiful variable lighting effects with remote pushbutton control. When the name plate says "Cutler-Hammer", you too can be sure of trouble-free performance "as specified". CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wis. *Assoc.:* Canadian Cutler-Hammer, Ltd., Tor.

Cutler-Hammer general purpose motor control is recommended by a majority of all electric motor manufacturers, is featured as standard equipment by machinery builders, is carried in stock by recognized electrical wholesalers everywhere.

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